

VIRGINIA RAILWAY EXPRESS



Quantico Station Improvements

IFB 020-019

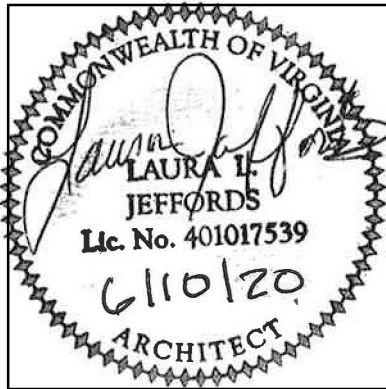
Technical Specifications

June 10, 2020

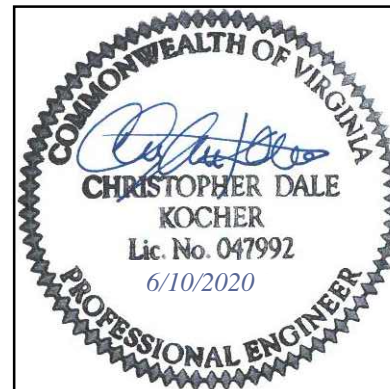
Invitation for Bid (IFB)

Technical Specifications
Seals Page**DESIGNER OF RECORD**

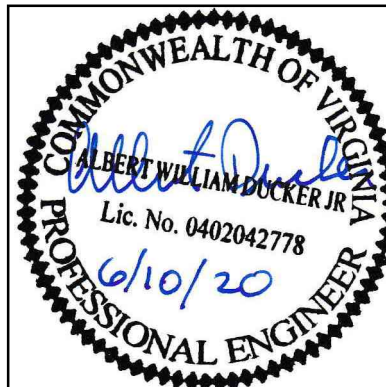
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REFERENCE THE APPENDICIES FOR ADDITIONAL SPECIFICATIONS AND REQUIREMENTS BY CSX. WHERE THERE IS AN OVERLAP IN REQUIREMENTS BETWEEN THE CSX SPECIFICATIONS AND THE PROJECT SPECIFICATIONS, THE MORE STRINGENT SHALL GOVERN THE WORK. REFERENCE THE APPENDICIES FOR ADDITIONAL SPECIFICATIONS AND REQUIREMENTS BY CSX TRANSPORTATION (CSXT). IF THERE IS A CONFLICT IN REQUIREMENTS BETWEEN THE CSXT SPECIFICATIONS AND THE PROJECT SPECIFICATIONS THAT AFFECTS THE PROPOSED WORK, THE CONTRACTOR SHALL IDENTIFY THE CONFLICT TO VRE. VRE WILL REVIEW THE CONFLICT AND ADVISE THE CONTRACTOR OF THE PREFERRED / APPLICABLE REQUIREMENT.

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Appendix A CSX Design and Construction Standard Specifications

Appendix B Requirements for Work on, over, or with the Potential to Impact CSX Property

Appendix C Geotechnical Engineering Report Quantico Station Redesign by Geoconcepts Engineering, Inc. dated March 29, 2016

Appendix D Geotechnical Engineering Report Retaining Wall No. 13 by Geoconcepts Engineering, Inc dated May 12, 2016 and Revised June 9, 2020.

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SECTION 01 11 00**Summary of Work****PART 1 - GENERAL****1.01 SUMMARY**

- A. This section includes the following:
1. Work included in Contract Documents
 2. Restrictions and Quality Control
 3. Damages and Pre-Existing Conditions
 4. Type of Contract
 5. Sequence of Work
 6. Work by Others
 7. Use of Premises
 8. Occupancy Requirements
 9. Utility Location, Protection and Relocation
 10. Utility Outages

1.02 RELATED SECTIONS

- A. Drawings, General Provisions, General Conditions, Special Provisions and other Division 01 Specifications apply to this Section.

1.03 WORK INCLUDED IN CONTRACT DOCUMENTS

- A. This section includes requirements for the construction of Quantico Station Improvements. The project consists of improvements to expand historic Quantico Station. The existing platform will be extended, and a new center platform will be provided. These platforms will be connected via a grade separated crossing in the form of a two pedestrian bridges between three stair/elevator towers. Track improvements in the immediate area will involve new alignments for tracks one through three and a new retaining wall. Other ancillary improvements will include new utilities and equipment along with landscaping.

1. Project Location:

Quantico station is located at CSX transportation (CSXT) milepost CFP 78.8 on the central division and RF&P subdivision in Quantico, VA. A third track is proposed and included in this project consistent to the sow and division of work for the overarching Arkendale to Powells creek project between mileposts CFP 78.21 and CFP 79.05 on the CSXT RF&P subdivision Quantico, VA.

Quantico station is located at 550 Railroad Ave, Quantico, VA 22134

Nearest grade crossing is fra#860605j at MP CFP 78.83, Potomac Avenue, Prince William County, VA.

- B. Engineer-of-Record (EOR): The Bid Documents, dated 10 June 2020, were prepared by STV Incorporated
- C. Construction Manager: VRE will engage a Construction Manager to be named for this Project to serve as an advisor to VRE and to provide assistance in administering the Contract for Construction between VRE and the Contractor, according to a separate contract between the VRE and Construction Manager.
- D. Project Manager: When a Construction Manager has not been engaged, VRE will designate a Project Manager (PM) to represent VRE and assist in monitoring the work under the Contract. In these instances, any reference to the Construction Manager, where it occurs in the Technical Specification documents, shall be understood to mean the Project Manager.
- E. The delivered project shall:
 - 1. Meet and/or exceed the requirements set forth elsewhere in the Contract Documents.
 - 2. Be capable of safe and reliable operation meeting and/or exceeding industry standards and practices.
- F. This Section outlines the main features of the Work to be performed under this Contract and is not a complete description. Work addressed in this Section but not addressed in other portions of the design shall still be considered part of the overall Work. The general details of the Work to be performed under this Contract are indicated more specifically in the other Specification sections, other documents of the design and other Contract Documents. The Work includes:
 - 1. The construction of site, civil, and drainage elements to include retaining wall 13 from approximately Sta. 8243+76 to Sta. 8269+91 proposed track #3 (from previous package 5 within the Arkendale to Powells creek project). This site/civil drainage component will include sub-ballast and up to the bottom of the ballast pad for railroad tie installation. CSX to provide ballast, tie, and rail installation, along with signal work, main line tie-ins, and grade crossing installation at Potomac avenue, as well as flagging for overall project and as needed for project as part of scope and requirements and budget for remaining Arkendale to Powells creek work for DRPT/FRA (per Arkendale agreement between CSX and DRPT sow and IRPOC funding agreement).
 - 2. Project scope shall also include the installation of a new island platform between proposed track 2 and proposed track 3, along with corresponding ped bridges both to the east and to the west, along with platform extension of existing side platform along the east of proposed track 1 per the dimensions, location, and geometry shown on the attached plan sheets, along with corresponding lighting and Americans with Disabilities Act (ADA) access (shown on plan sheets as well), at the Quantico station.

3. The Contractor shall furnish all qualified and certified labor, material, equipment, permit(s), licenses, and insurance to complete construction of the Project as indicated in the plans and specifications. The contractor shall install all work in compliance with all requirements of the host railroad, CSX Transportation (CSXT), along with any permit(s) or coordination requirements of the local jurisdictions and utilities to enable the facility to be put into service.
 4. Right-of-Entry (ROE) obtained from host railroad within VRE/CSX construction agreement, flagging provided by CSX and charged to Arkendale to Powells creek third track project per agreement between CSX and DRPT. Contractor to provide beneficial use within 730 calendar days of NTP. The contractor shall coordinate and communicate schedules, critical paths and milestones with VRE and stakeholders.
 5. The contractor shall be responsible for, but not limited to, the following tasks:
 6. Obtaining all necessary permit(s) that have not already been obtained by VRE as noted in IFB and contract documents.
 7. Coordination of construction activities and flagging with CSXT, including the preparation of submittals, as noted in the plans and specifications, for approval by VRE, CSXT and all other stakeholders as applicable.
 8. Technical submittals, shop drawings and construction layout.
 9. Maintaining commuter access to the existing Quantico station platforms throughout construction.
 10. Mobilization/demobilization and installation of any temporary devices as required by CSXT, MCBQ, dominion energy, or the local jurisdictions as needed.
- G. Potential Impacts and Mitigations
1. VRE intends to coordinate closely with the adjacent stakeholders and property owners (CSX, marine corps base Quantico (MCBQ) Prince William County, utilities, MCBQ, and town of Quantico) for any required access or permit requirements not identified in the design and procurement process.
 2. Access for Quantico station improvements to be utilized on MCBQ property through existing access agreements between CSX and MCBQ temporary construction permits as coordinated and agreed to previously. CSX to extend construction permits (temporary construction access) for duration of Quantico station improvements project. Contractor is required to coordinate all utility locates/dig tickets and notifications with Miss Utility, MCBQ, CSX, and town of Quantico.
 3. Final property ownership transfer to be negotiated with MCBQ (NAVFAC) and CSXT upon final completion and final survey of as built conditions for 4'+ strip on west side of existing CSX/MCBQ row line as well as bump out for final location of west tower for ped bridge.

4. The contractor shall arrange operations and perform construction activities in a manner that always maintains temporary and permanent railroad clearances and train movements. Clearances and any need for track protection provided by a host railroad representative will be scheduled with the local roadmaster in a manner consistent with railroad protection manpower availability.
 5. CSX will coordinate relocation of century link fiber optic line as needed for 3rd track installation.
 6. Typical FAE costs, flagging, track work, signal protection, signal work, grade crossing work, etc. To be borne by Arkendale to Powells creek third track project (see attached sow).
 7. All of the above have been designed and will be constructed in accordance with CSXT design and construction standards and have been submitted and have received CSXT review previously, with any comments resolved as part of stakeholder review process for Arkendale project.
 8. Track cut-ins and track cutovers will be needed as part of CSX scope for Arkendale project once site, civil, drainage, retaining wall, and sub-ballast have been installed.
 9. Potomac avenue grade crossing installation will need to be coordinated between VRE and contractor and CSX forces, along with corresponding utility location, utility protection, and signal work.
 10. All the above have been designed and will be constructed in accordance with CSXT design standards. The proposed improvements will be constructed of durable, maintainable materials with methods of installation having a minimum impact on train operations. This includes the installation of concrete platforms, steel canopies, sheet metal roofing, lighting, ticket vending machines, variable message system, security cameras, electrical connections, and water connections as needed on the platform, and pedestrian access.
- H. Ownership of materials:
1. Materials furnished by the Contractor under this contract shall become the property of VRE.
 2. VRE-furnished materials shall remain the property of VRE.

1.04 RESTRICTIONS AND QUALITY CONTROL

- A. The overall site plan and facilities configurations as depicted in the design are mandatory and shall not be altered except as approved by the Engineer.
- B. All site features and the facility shall be in accordance with Virginia Railway Express' requirements as defined herein.

1.05 DAMAGES AND PRE-EXISTING CONDITIONS

- A. Contractor shall be responsible for all damages caused by Contractor's construction activities. Provide all labor, materials, etc. to return any damaged areas, systems or equipment to their original condition at no additional cost to VRE.
- B. Perform a survey of pre-existing conditions in the vicinity of Contractor's construction activities, utilizing photographs and other means as necessary to document existing damage or conditions. Submit two copies of this survey to the CM within 21 calendar days after Notice-to-Proceed. Survey shall be approved by VRE prior to submission of first invoice by the Contractor. This survey will assist in resolving any damage claims against the Contractor during and after construction.
- C. Unless noted otherwise preserve all facilities and portions thereof including but not limited to roadways, pedestrian and directional signage. Deliver all removed facilities not required for reinstallation to VRE as directed by the CM.
- D. Replace or repair lost or damaged facilities or portion thereof, to the satisfaction of VRE, at no cost to VRE.

1.06 TYPE OF CONTRACT

- A. This project will be constructed under a general construction contract.

1.07 SEQUENCE OF WORK

- A. Conduct the Work in one continuous operation. If phased construction is required, the Contractor shall arrange the sequence of construction, unless noted otherwise on the Contract Plans.
- B. Work shall be performed in accordance with the Contractor's "CPM Construction Schedule" as specified in Division 01 Section "Construction Progress Documentation: and as approved by the Construction Manager.

1.08 WORK BY OTHERS

- A. General: Cooperate fully with other entities (e.g. Host Railroad, Utility Owner) so their work may be performed without interfering or delaying work within this Contract. Coordinate the Work of this Contract with work performed by other entities with the CM.

VRE understands that work to be performed by others as part of this projects includes:

1. Relocation of underground fiber optic conduit/conductor by Century Link (or contractor).
2. Protection, or relocation if required, of fiber optic conduit/conductor by Verizon (or contractor)
3. Grade-crossing relocation and construction by CSXT (or contractor).
4. Track and Signal/Communications construction by CSXT (or contractor).
5. Power pole and line relocation by MCBQ (or contractor).
6. Installation of gas line by Columbia Gas (or contractor).

- B. Preceding Work: VRE will award separate contract(s) for the following construction operations at the Project site. Those operations are scheduled to be substantially complete before work under this Contract begins.
 - 1. No separate contracts are known for work preceding this Contract.
- C. Concurrent Work: VRE will award separate contract(s) for the following construction operations at the Project site. Those operations will be conducted simultaneously with work under this Contract.
 - 1. Installation of Ticket Vending Machine (TVM) equipment by VRE.
 - 2. Installation of Variable Messaging System (VMS) equipment by VRE.
 - 3. Installation of Security Cameras by VRE.
- D. Future Work: VRE will award separate contract(s) for the following additional work to be performed at the Project site after Substantial Completion. Completion of that work will depend on successful completion of preparatory under this Contract.
 - 1. No separate contracts are known for future work after this Contract.
- E. For additional requirements for Cooperation Among Contractors, see Division 01, Section 01 73 00 "Execution of Work."

1.09 USE OF PREMISES

- A. Use of Site: Confine use of premises to work in areas indicated. Do not disturb portions of site beyond limits of construction areas in which the Work is indicated.
 - 1. Limits: Confine construction operations to areas where work and staging is shown on plans.
 - 2. VRE Access: Allow VRE and their designees to have unencumbered access to areas designated for VRE. Access to areas, restricted due to construction, shall be coordinated by the Construction Manager, for VRE personnel involved in the performance of the construction contract. The remainder of the site, including newly constructed areas, shall be restricted to only VRE personnel involved in the performance of the construction contract, as designated by the Construction Manager, until VRE establishes occupancy of the project site.
 - 3. Contractor shall have full use of premises for construction operations within the designated Limits of Construction as indicated on the Contract Plans, during the hours indicated and as directed by the Construction Manager.
 - 4. Unless noted otherwise, the Contractor shall keep the site free from accumulation of waste materials. When the project is complete, the Contractor must remove from and about the project site, waste materials, tools, construction equipment, machinery and surplus materials. If a dispute arises regarding maintenance or clean-up of the premises, VRE may maintain and clean the site and assess actual damages to the Contractor.

5. The Contractor must remain aware that the areas of work are active rail lines. Extreme caution and safety must be exercised at all times.
- B. Utilize areas designated for Contractor staging, storage and parking as indicated on the Contract Drawings. For additional requirements, see Division 01, Section 01 50 00.
- C. Use of Existing Facilities: Maintain existing facilities in a weather tight condition throughout construction period. Repair damage caused by construction operations. Protect facilities and their occupants during construction period.
- D. Use of Explosives: Explosives shall not be used on site, unless approved in writing by VRE.

1.10 OCCUPANCY REQUIREMENTS

- A. Partial VRE Occupancy: VRE reserves the right to occupy, use and/or to place and install equipment in any completed or partially completed areas of the site/building, before Substantial Completion, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and partial occupancy shall not constitute acceptance of the total Work. Partial VRE occupancy requirements are as follows:
 1. Construction Manager will prepare a Certificate of Substantial Completion for each specified portion of the Work to be occupied before VRE occupancy.
 2. Before partial VRE occupancy, mechanical and electrical systems shall be fully operational and required tests and inspections shall be successfully completed. On occupancy, VRE will operate and maintain mechanical and electrical systems serving occupied portions of the building/site.
 3. On occupancy, VRE will assume responsibility for maintenance and custodial service for occupied portions of building.

1.11 UTILITY LOCATION, PROTECTION AND RELOCATION

- A. Coordinate utility location services to identify and mark the location of all utility lines, that may be impacted by construction activities, including but not limited to the following:
 1. Electric power lines
 2. Natural gas lines
 3. Sanitary sewers
 4. Stormwater/drainage
 5. Water supplying piping
 6. Petroleum/Fuel lines
 7. Telephone lines
 8. Data and Communication/ Fiber Optic Lines
 9. Underground Storage Tanks
 10. Steam/water lines

11. Underground utilities and lines abandoned in place

- B. The information in the Contract Documents concerning the type and location of utilities is neither guaranteed nor inclusive. The Contractor is responsible for determining the type and location of utilities, regardless of whether such utilities are indicated or not, so as to avoid damage thereto.
- C. Check and verify the horizontal and vertical location (coordinates and elevation) of all utility lines that may exist within the limits of new work, regardless of whether such utilities are indicated or not, by use of a Subsurface Utility Engineering company. Reconfirm such locations and verification of utilities discovered, regardless of whether such utilities are indicated or not, and submit to the Project Manager a dimensional survey with such notations.
- D. Test pits shall be accomplished by means of non-destructive testing in the vicinity of the discovered utilities, as indicated on the Contract Plans. Additional test pits may be performed by the Contractor, at their expense, in coordination with the CM and applicable utility.
- E. Repair any damage to discovered utility lines due to construction operations at no expense to VRE. VRE will assist the Contractor by making available any known information.
- F. If utilizing an independent subsurface utility engineering company, submit the name of firm and qualifications to the CM, for written approval.
- G. Within 60 calendar days of Notice to Proceed, submit to the CM a survey of all utility location results.
- H. For additional requirements for Cooperation with Utility Companies, see Division 01, Section 01 73 00 "Execution of Work."

1.12 UTILITY OUTAGES

- A. Prior to any utility outage/interruption, prepare a schedule of such outage. Include in outage schedule duration, identification of the service affected, temporary utility service to be provided, identification of available service alternative, and the action to be taken in the event of any emergency. Apply for all outages of utility systems in writing. Fully coordinate outage requests with the Construction Manager. Schedule shall include date, time, and duration of outage. Obtain approval in writing by the Construction Manager.

PART 2 – PRODUCTS - NOT USED.

PART 3 – EXECUTION -NOT USED.

END OF SECTION

SECTION 01 22 00**Unit Prices****PART 1 - GENERAL****1.01 SUMMARY**

Section includes administrative and procedural requirements for unit prices and only applies to Unit Price contracts.

1.02 RELATED SECTIONS

- A. Drawings
- B. General Provisions
- C. General Conditions for Construction
- D. Special Provisions
- E. Section 01 26 00 – Change Order Procedures
- F. Section 01 29 00 – Payment Procedures

1.03 DEFINITIONS

Pay Item: A specifically described unit of work for which a Unit Price is provided in the Contract.

Unit Price: An amount proposed by bidders, stated on the Bid or Proposal Form, incorporated in the Agreement and applicable during the duration of the Work as a price per unit of measurement for materials, equipment, or services, or a portion of the Work, added to or deducted from the Contract Sum by appropriate modification, if the scope of Work or estimated quantities of Work required by the Contract Documents are increased or decreased.

1.04 PROCEDURES

- A. Unit prices include all necessary material, cost for delivery, installation, insurance, applicable taxes, overhead, and profit. The sum of all extended unit prices in the Bid or Proposal Form, shall be deemed to include all work described in the Contract Documents including Contract Plans and Specification.
- B. Payments to the Contractor will be made for the actual quantities of Contract items performed in accordance with the plans and the requirements of the Specifications and other Contract documents. If, upon completion of the Work, the actual quantities vary, either by an increase or decrease from the estimated quantities shown in the Contract, the Contract unit prices shall prevail and payment will be made for actual quantities performed at such unit prices, unless the unit prices have been modified by a Contract Amendment.
- C. No allowance or other adjustment will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting directly from such variance, or from the Contractor's unbalanced allocation among the Contract

- items of overhead expense and subsequent loss of expected reimbursements therefore, or from any other cause.
- D. Quantities appearing on the bid sheet are estimated quantities for the basic design shown on the plans. With VRE's approval, the Contractor may furnish other design(s) that may involve changes in quantities or the use of different materials. However, payment will be made for the original quantities listed in the Contract only and in the units of measure given in the Contract for the basic design unless the dimensions for the basic design are changed by an authorized change order to conform to field conditions encountered. In this event, the original quantities listed will be modified based on the change in dimension, and the modified quantities will be used for paying quantities at Contract unit prices for the items listed on the bid sheet.
- E. In the event the actual quantity of Work performed exceeds or is below the estimated quantity by more than 10%, a Contract Amendment will be issued.
- F. When the accepted quantity of a unit price pay item increases or decreases more than 25% of the original Contract quantity, an equitable adjustment in the unit price may be negotiated if requested by the Contractor or VRE. The equitable adjustment shall be made upon any increase or decrease in cost due solely to the variation less than 75% or in excess of 125% of the estimated quantity and shall apply to the actual amount of work performed.
- G. If the quantity variation is such as to cause an increase in time necessary for completion, the Contractor may request, in writing, an extension of time, to be received by the CM within ten (10) calendar days from the beginning of the delay, or within such further period as may be granted by VRE before the date of final settlement of the contract. Upon the receipt of a written request for an extension, VRE shall ascertain the facts and make an adjustment for extending the completion date as, if in the judgement of VRE, is warranted.
- H. The Contractor shall accept the compensation provided for in the Contract as full payment for the following:
1. Furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the Work according to the Contract.
 2. Performing all work specified in the Contract.
 3. All loss or damage arising from the nature of the Work or from action of the elements or any other unforeseen difficulties that may be encountered during prosecution of the Work and until its final acceptance.
 4. Any license, use, or infringement of a patent, trademark, or copyright.
 5. The completion of the Work in accordance with the Contract requirements.
- I. The Contractor shall notify the Construction Manager (CM) when items of work are ready for measurement. The Contractor and CM or Inspector shall coordinate on site to measure the work in place for payment according to the requirements of this Specification Section. The CM may question or reject the Contractor's measurement of work-in-place if the Contractor and CM have not measured the work together or come to an agreement on the measured quantities.

VRE reserves the right to reject the Contractor's measurement of work-in-place that involves the use of established unit prices and to have this work measured, at VRE's expense, by a qualified independent 3rd party acceptable to the Contractor.

- J. At the discretion of VRE, payment may be reduced for any Work which is not in full compliance with the Contract Documents or which has been damaged or repaired by the Contractor. Such action may be used when the end product may have a reduced service life or less than desirable aesthetic characteristics.

1.05 MEASUREMENT OF QUANTITIES

A. General

1. Work specified in the Contract will be measured by the CM in accordance with U.S. Standard Measure. The methods of measurement and computations to be used to determine quantities of material furnished and work performed will be those generally recognized as conforming to good engineering practice.
2. Specific methods of measurement shall be as indicated in the specific Section for the Contract item.
3. Longitudinal measurements for surface area computations will be made along the surface (horizontally), and transverse measurements will be the surface measure shown on the plans or ordered in writing by the CM. Individual areas of obstructions with a surface area of 9 square feet or less will not be deducted from surface areas measured for payment.
4. Structures will be measured in accordance with the neat lines shown on the plans or as otherwise approved in writing.
5. Items that are measured by the linear foot will be measured parallel to the base or foundation upon which they are placed.
6. Allowance will not be made for surfaces placed over an area greater than that shown on the plans or for any material moved from outside the area of the cross-section and lines shown on the plans.
7. When standard manufactured items are specified, and are identified by weights or dimensions, such identification will be considered nominal. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

B. Measurement by Weight

1. Materials that are measured or proportioned by weight shall be weighted on accurate scales as specified in this Section.
2. The Contractor shall have the weigh person perform the following:
 - a. Furnish a signed weigh ticket for each load that shows the date, load number, plant name, size and type of material, project number, schedule or purchase order number, and the weights specified herein.

- b. Maintain sufficient documentation so that the accumulative tonnage and distribution of each lot of material, by Contract, can be readily identified.
 - c. Submit by the end of the next working day a summary of the number of loads and total weights for each type of material by Contract.
3. Trucks used to haul material shall be equipped with a cover suitable to protect the material and to protect the traveling public.
4. The truck tare to be used in the weighing operation shall be the weight of the empty truck determined with full tank(s) of fuel and the operator seated in the cab. The tare weight of trucks shall be recorded to the nearest 20 pounds. At the option of the Contractor, a new tare may be determined for each load. When a new tare is obtained for each load, the requirement for full tank(s) of fuel will be waived.
5. Net rail shipment weights may be used for pay quantities when evidenced by railroad bills of lading. However, such weights will not be accepted for pay quantities of materials that subsequently pass through a stationary mixing plant.
6. Scales shall conform to the requirements for accuracy and sensitivity as set forth in the National Institute of Standards and Technology Handbook No. 44 for Specification Tolerances and Requirements for Commercial and Weighing Devices. Scales used in the weighing of materials paid for on a tonnage basis shall be approved and sealed in accordance with the requirements of the policies of the Bureau of Weights and Measures of the Department of Agriculture and Consumer Services, or other approved agencies, at least once every six months and upon being moved. Hopper and truck scales shall be serviced and tested by a scale service representative at least once every six months. Hopper scales shall be checked with a minimum 500 pounds of test weights and truck scales shall be checked with a minimum 20,000 pounds of test weights.
7. Copies of scale test reports shall be maintained on file at the scale location for at least 18 months, and copies of all scale service representative test reports shall be forwarded to VRE upon request.
8. The quantity of materials paid for on a tonnage basis shall be determined on scales equipped with an automatic printer. Truck scale printers shall print the net weight and either the gross or tare weight of each load. Hopper scale printers shall print the net weight of each load. The weigh ticket shall also show the legal gross weight for material weighed on truck scales and the legal net weight for material weighed on hopper scales.
9. If the automatic printer becomes inoperative, the weighing operation may continue for 48 hours provided satisfactory visual verification of weights can be made. The written permission of the VRE shall be required for the operation of scales after 48 hours.
10. If significant discrepancies are discovered in the printed weight, the ultimate weight for payment will be calculated on volume measurements of the materials in place and unit weights determined by the CM or by other methods deemed appropriate to protect the interests of VRE.

C. Measurement by Volume (e.g. Cubic Yard)

1. Material that is measured by the cubic yard, loose measurement or vehicular measurement, shall be hauled in approved vehicles and measured therein at the point of delivery. Material measured in vehicles, except streambed gravel, silt cleanout, or other self-consolidating material will be allowed at the rate of 2/3 the volume of the vehicle. The full volume of the vehicle will be allowed for streambed gravel. Such vehicles may be of any size or type acceptable to the Engineer provided the body is of such shape that the actual contents can be readily and accurately determined. Unless all approved vehicles are of uniform capacity, each vehicle shall bear a plainly legible identification mark indicating the specific approved capacity. Each vehicle shall be loaded to at least its water level capacity.
2. When approved by the CM in writing, material specified to be measured by the cubic yard may be weighed and such weights converted to cubic yards for payment purposes. Factors for conversion from weight to volume measurement will be determined by the CM and shall be agreed to by the Contractor before they are used.

D. Measurement by Lump Sum

1. When used as an item of payment, the term lump sum will mean full payment for completion of the corresponding item of work described in the Contract. When a complete structure or structural unit is specified as a Contract item, the unit of measurement will be lump sum, and shall include all necessary fittings and accessories. The quantities may be shown on the plans for items for which lump sum is the method of measurement. If shown, the quantities are approximate and are shown for estimating purposes only and no measurement of quantities will be made for payment. Items that are to be measured as complete units will be counted by the VRE Representative in the presence of a representative of the Contractor.

E. Measurement by Length (e.g. Linear Foot or Vertical Linear Foot)

1. When used as an item of payment, the term of length will mean full payment for completion of the corresponding item of work described in the Contract. When a pay item unit is specified as a Contract item, the unit of measurement designated as a unit of length shall include all necessary fittings and accessories. The quantities may be shown on the plans for items for which length is the method of measurement. Items that are to be measured as complete units will be counted by the Inspector in the presence of a representative of the Contractor.

F. Measurement by Area (e.g. Square Feet)

1. When used as an item of payment, the term of area will mean full payment for completion of the corresponding item of work described in the Contract. When a pay item unit is specified as a Contract item, the unit of measurement designated as a unit of area shall include all necessary fittings and accessories. The quantities may be shown on the plans for items for which are is the method of measurement. Items that are to be measured as complete units will be counted by the Inspector in the presence of a representative of the Contractor.

G. Measurement by Item or Count (e.g. Each)

1. When used as an item of payment, the term of item or count will mean full payment for completion of the corresponding item of work described in the Contract. When a pay item unit is specified as a Contract item, the unit of measurement designated as a unit of item or count shall include all necessary fittings and accessories. The quantities may be shown on the plans for items for which are is the method of measurement. Items that are to be measured as complete units will be counted by the Inspector in the presence of a representative of the Contractor.

1.06 PLAN QUANTITIES

- A. When specified in the Contract, Contract items will be measured and paid for on the basis of plan quantities. The quantities allowed for compensation will be those shown on the plans with deductions from or authorized additions to such quantities resulting from authorized deviations from the plans.
- B. In the case of excavation, only excavation within the cross-section prism will be paid for on a plan quantity basis.
- C. If the Contractor believes that any plan quantity is incorrect, they may solicit, at their own expense, the aid of a Professional Engineer licensed to practice engineering in the State, Commonwealth, or District where the project is physically located to check the quantity or they may ask the CM in writing to check computations of the quantity. Written requests for a quantity check by the CM shall be accompanied by calculations, drawings, or other evidence indicating why the plan quantity is believed to be in error. If any item of the Contract is found to be in error and so verified by the CM, payment will be made in accordance with the corrected plan quantity.
- D. If the CM or VRE determines during construction that there is an error in the plan quantity, or that conditions vary from those anticipated in the design to the extent that an actual measurement of a plan quantity item is warranted, the CM will make such measurement and will notify the Contractor, in writing, of the rationale for adjustment. Payment will then be based on the measured quantity in lieu of the plan quantity.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 24 00**Value Engineering****PART 1 - GENERAL****1.01 SUMMARY**

Section includes procedures and requirements related to Value Engineering Proposals.

1.02 RELATED SECTIONS

- A. Section 01 25 00 – Substitution Procedures
- B. Section 01 33 00 – Submittal Procedures

1.03 VALUE ENGINEERING PROPOSALS

- A. The Contractor may submit to VRE written Value Engineering Proposals (VEP) for modifying the plans, Specifications, or other Contract requirements for the purpose of reducing the total cost and/or Contract time without reducing the design capacity, intended purpose, or quality of the finished product. If VRE accepts the VEP, VRE and the Contractor will divide the net savings as enumerated in section 1.05., Contract time or both. The requirements herein apply to each VEP initiated, developed, and identified as such by the Contractor at the time of its submission to VRE. However, nothing herein shall be construed as requiring VRE to approve a VEP.

1.04 VEP REQUIREMENTS

- A. The Contractor's VEP shall clearly demonstrate that changing the contract requirements would:
 - 1. Result in a net reduction in the total contract amount;
 - 2. Not impair, in any manner, the essential functions or characteristics of the project, including but not limited to, service life, economy of operation ease of maintenance, desired appearance, design and safety standards; and
 - 3. Not detrimentally affect the project completion schedule.
 - 4. VEPs will not be considered if proposed materials cannot be procured and delivered within the approved construction schedule.
- B. Each VEP shall result in a net savings over the Contract cost or Contract time, or both, without impairing essential functions and characteristics of the item(s) or of any other part of the project, including, but not limited to, service life, reliability, economy of operation, ease of maintenance, aesthetics, and safety. At a minimum the following information shall be submitted with each VEP:
 - 1. Statement that the proposal is submitted as a VEP;
 - 2. A description of both existing contract requirements for performing the work and the VEP, with a discussion of the comparative advantages and disadvantages of each;

3. Statement concerning the basis for the VEP benefits to VRE and an itemization of the pay items and contract requirements affected by the VEP, if adopted;
4. Detailed estimate of the cost of performing the work under the existing Contract and under the VEP;
5. A statement of the effect adoption of the VEP will have on the time for completion of the contract.
6. Proposed specifications and recommendations as to the manner in which the VEP changes are to be accomplished;
7. Statement as to the time by which a Contract Amendment adopting the VEP must be issued so as to obtain the maximum cost-effectiveness. Said date shall be selected so as to preclude all schedule impacts to the project regardless of whether work proceeds as specified in the contract or as specified in the VEP;
8. A statement from the Contractor predicting any effects the proposed VEP will have on the life-cycle cost of the work to include and identify separately the cost for increased or decreased maintenance and operations.
9. A description and estimate of costs VRE may incur in implementing the VEP, such as redesign, evaluation, tests and operating and supporting costs.

1.05 VEP SAVINGS SHARING BETWEEN THE CONTRACTOR AND VRE

- A. If VRE accepts the VEP, an equitable adjustment in the contract amount shall be determined in accordance with the following:
 1. Net savings shall be shared between VRE and the Contractor will be divided on the basis of sixty percent (60%) for the Contractor and forty percent (40%) for VRE.
 2. Net savings shall be determined by (1) deducting from the estimated gross savings, the Contractor's cost of implementing the VEP (including subcontractor costs, if applicable) and (2) adding the estimated amount of increased costs to VRE resulting from the change, such as testing, redesign, implementation, and related items.
 3. Estimated gross savings shall include the Contractor's labor, material, equipment, overhead, profit and bonds.
 4. When an accepted VEP includes Contract time savings, one-half of such time savings shall be used to reduce the Contract time and the remaining one-half of such time savings shall be used exclusively by the Contractor as extra time. A Revised Baseline Schedule shall be prepared, in which the Contractor shall identify a VEP contractor float activity for each accepted VEP that includes Contract time savings. The VEP extra time may be used by the Contractor to mitigate its delays on the project.
 5. The contract amount shall be reduced by VRE's share of the net savings.
- B. VRE will be the sole judge of the acceptability of a VEP and of the estimated net savings from the adoption of all or any part of such proposal. In determining the estimated net savings, VRE

may disregard the contract line item prices, if in VRE's judgement such prices do not represent a fair measure of the value of the work to be performed or deleted.

1.06 VEP SUBMISSION AND PROCESSING

- A. The Contractor shall submit three (3) copies of the VEP along with all supporting information to the CM. The CM shall notify the Contractor of the status of the VEP within 30 calendar days after receipt. If additional time is required for evaluation, the CM shall notify the Contractor within the 30-day period and provide the reason for the delay.

Unless this notification specifically states otherwise, the provisions of paragraph C below and the following shall prevail:

1. The Contractor shall continue to perform the work in accordance with the requirements of the contract; and
 2. Failure of VRE to adopt the VEP by the date specified in the VEP, or the date subsequently specified in writing, shall be deemed rejection of the VEP.
- B. Final VEP submittals shall contain calculations and drawings signed and sealed by a professional engineer licensed in the Commonwealth of Virginia or District of Columbia.
- C. VRE will process the VEP in the same manner as prescribed for any other proposal that would necessitate issuance of a Contract Amendment. VRE may accept a VEP in whole or part by issuing a Contract Amendment that will identify the VEP on which it is based. The Contract Amendment will provide for an equitable adjustment in the contract amount and will revise any other affected provisions of the contract documents.
- D. VRE will not be liable to the Contractor for failure to accept or act on any VEP submitted pursuant to these requirements or for delays in the work attributable to any VEP. Until a VEP is put into effect by a Contract Amendment, the Contractor shall remain obligated to the terms and conditions of the existing Contract. If an executed Contract Amendment has not been issued by the date on which the Contractor's proposal specifies that a decision should be made or such other date as the Contractor may subsequently have specified in writing, the VEP shall be deemed rejected.
- E. The Contract Amendment effecting the necessary modification of the Contract will establish the net savings agreed on and provide for adjustment of the Contract prices or Contract time, or both. The Contractor shall absorb all costs incurred in preparing a VEP. Costs for reviewing and administering a VEP will be borne by VRE. VRE may include in the agreement any conditions it deems appropriate for consideration, approval, and implementation of the VEP. The Contractor's 50 percent share of the net savings or Contract time, or both, shall constitute full compensation for effecting all changes pursuant to the VEP Contract Amendment.
- F. Unless specifically provided for in the Contract Amendment authorizing the VEP, acceptance of the VEP and performance of the work thereunder will not change the Contract time limit.
- G. VRE may adopt a VEP for general use in contracts VRE administers if it determines that the VEP is suitable for application to other contracts. VEPs identical with or similar to previously submitted VEPs will be eligible for consideration and compensation under these provisions if VRE has not previously adopted the VEPs for general application to other contracts VRE

- administers. When a VEP is adopted for general use, compensation pursuant to these requirements will be applied only to those awarded contracts for which the VEP was submitted prior to the date of adoption of the VEP.
- H. Proposed changes in the basic design of the Project or those changes that require different right of way limits will not normally be considered an acceptable VEP. If a VEP is based on, or is similar to, a change in the plans, Specifications, or Special Provisions VRE has adopted prior to submission of the VEP, VRE will not accept the VEP.
- I. Subject to the provisions herein, VRE or any other public agency shall have the right to use all or part of an accepted VEP without obligation or compensation of any kind to the Contractor.

1.07 PRELIMINARY VEPS

- A. The Contractor may submit a Preliminary value engineering proposal (Preliminary VEP) to VRE to determine whether an idea is considered feasible and to assist the Contractor in determining whether a formal VEP should be developed and submitted.
- B. A Preliminary VEP shall be brief, one to two pages if possible, and comprehensive. At a minimum, it should:
1. Describe the technical concept being contemplated;
 2. Describe other, non-technical factors critical to analysis of the potential VEP such as schedule impacts, aesthetic considerations, operational and maintenance impacts, etc.
 3. Provide an order-of-magnitude estimate of the net cost savings which may be realized for the potential VEP; and
- C. Submitting a Preliminary VEP:
1. Does not establish ownership of a value engineering idea;
 2. Does not establish a right to share in any resultant savings;
- Ownership of a value engineering idea is not established until a fully documented formal VEP is submitted.
- D. VRE will review the Preliminary VEP within fifteen (15) business days and indicate if the idea(s) presented:
1. Have potential;
 2. Could be modified to have potential; or
 3. Have little or no chance of being accepted.
- E. Indication by VRE that a preliminary VEP has potential does not guarantee that the subsequent formal VEP will be accepted. VRE shall be the sole judge of the acceptability of a formal VEP and reserves the right to reject a VPE for any reason including technical, nontechnical, financial or contractual reasons.
- F. Submittal of Preliminary VEPs is not a requirement and is strictly optional. However, submittal of a Preliminary VEP can reduce the Contractor's risk by identifying those ideas that have little or no chance of being accepted.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 25 00

Substitution Procedures

PART 1 - GENERAL

1.01 SUMMARY

Section includes administrative and procedural requirements for major material substitutions after Notice of Award of Contract.

1.02 RELATED SECTIONS

- A. General Conditions for Construction
- B. Section 01 33 00 – Submittal Procedures

1.03 GENERAL

- A. The Contract is based on the materials, equipment and methods described in the Contract documents that allow for compliance to all Federal, State, and Local rules and regulations. No substitutions or cancellations shall be permitted after award without the written approval of VRE. VRE will consider requests for substitutions of materials, equipment and methods only when requests are accompanied by full and complete technical data and all other information required to evaluate the proposed substitution.
- B. Substitutions, if approved, shall be without any additional compensation except when provisions for SECTION 01 24 00 Value Engineering are applicable or extension of contract time from VRE, unless approved otherwise.

1.04 SUBMITTALS

- A. Timing:
 - 1. Submit substitution requests within a maximum of 45 calendar days after Notice to Proceed or as otherwise necessary and coordinated with the CM . Requests received after that time may be considered or rejected at the sole discretion of VRE. Substitutions will not be considered if they cannot be procured and delivered within the approved construction schedule.
- B. Conditions:
 - 1. VRE will consider Contractor's request for substitution only when the following conditions are satisfied. If the following conditions are not satisfied, the CM will return requests without action, except to record noncompliance with these requirements:
 - a. Requested substitution does not require extensive revisions to the Contract Documents.
 - b. Requested substitution is consistent with the Contract Documents and will produce indicated results.
 - c. Substitution request is fully documented and properly submitted.

- d. Requested substitution will not adversely affect Contractor's Construction Schedule.
 - e. Requested substitution has received necessary approvals of authorities having jurisdiction.
 - f. Requested substitution is compatible with other portions of the Work.
 - g. Requested substitution has been coordinated with other portions of the Work.
 - h. Requested substitution provides specified warranty.
 - i. If requested substitution involves more than one Contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all Contractors involved.
- C. Identify specified product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.
- D. Show compliance with requirements for substitutions and the following, as applicable:
- 1. Statement indicating why specified product or fabrication or installation cannot be provided, if applicable.
 - 2. Coordination information, including a list of changes or revisions needed to other parts of the Work that will be necessary to accommodate proposed substitution.
 - 3. Detailed comparison of significant qualities of proposed substitution with those of the Work specified. Significant qualities include attributes such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated.
 - 4. Indicate deviations, if any, from the Work as specified.
 - 5. Detailed information regarding any change in cost or contract time, including the cost of additional engineering required to properly incorporate proposed substitution.
 - 6. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
 - 7. Samples, where applicable or requested.
 - 8. Certificates and qualification data, where applicable or requested.
 - 9. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.
 - 10. Drawings as required to demonstrate details of the proposed product.
 - 11. Technical specification for the proposed product, if not included in the original contract.
 - 12. Contractor's certification that proposed substitution complies with requirements in the Contract Documents except as indicated in substitution request, is compatible with related materials, and is appropriate for applications indicated.

13. Contractor's certification waiving rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.
- E. If necessary, the CM will request additional information or documentation for evaluation within 15 days of receipt of a request for substitution. The CM will provide written acceptance or rejection of proposed substitution within 30 days of receipt of request, or 30 days of receipt of additional information or documentation, whichever is later.
- F. Do not use the RFI process for submittal of Substitution Requests.
- G. Contractor's submittal and VRE's review or approval Shop Drawings, Product Data or Samples related to a substitution does not itself constitute a final approval of the requested substitution, nor does it relieve the Contractor from fulfilling existing Contract requirements.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 26 00
Change Order Procedures

PART 1 - GENERAL

1.01 SUMMARY

Section includes procedures and requirements related to handling and processing Change Orders to include:

- A. Change Order Procedures
- B. Preparation of Proposed Change Orders
- C. Lump Sum Change Orders
- D. Unit Price Change Orders
- E. Time and Material Change Orders
- F. Contract Time Extensions
- G. Change Orders for Compensable Delay
- H. Differing Site Conditions
- I. Payment for Contract Amendment Work

1.02 RELATED SECTIONS

- A. 01 22 00 – Unit Prices
- B. 01 29 00 – Payment Procedures
- C. 01 32 00 – Construction Progress Documentation
- D. General Conditions for Construction

1.03 MINOR CHANGES IN WORK

- A. VRE shall have authority to make minor changes in the Work by supplemental instructions when such changes do not involve extra cost and are not inconsistent with the purpose of the Project. Otherwise, except in an emergency endangering life or property, no extra Work or change shall be made unless in pursuance of a written Construction Change Directive or Change Order and no claim for an addition to the Contract Amount or Contract Time shall be valid unless so ordered. If the Contractor believes a cost is associated with the supplemental instructions, the Contractor is to provide written notice to the CM within seven (7) days of receipt of instructions.

1.04 CHANGE ORDER PROCEDURES**A. Changes to the work can be by:**

1. Change Order issued by VRE to the Contractor.
2. Contractor proposing a Potential Change Order (PCO) to VRE.
3. Time and Material

Specific requirements for a VRE ordered change or preparation and submission of a Contractor PCO are detailed in the following subsections of this specification.

B. If any change causes an increase or decrease in the Contractor's cost of, or time required for, the performance of any part of the Work under the Contract, the Contracting Officer shall make an equitable adjustment and amend the Contract in writing. Approval may be contingent on funding agency or VRE Board authorization. VRE will issue a Contract Amendment all-inclusive of the terms of the Change Order (s) to the Contractor for signature. Once the Contract Amendment has been signed by the Contractor and VRE, it is considered executed.

1. VRE may require additional bond protection when a Contract price is increased. Such change will require notice to sureties and require that Performance and Payment Bonds be increased by the Contractor. The increase in protection shall generally equal one hundred percent (100%) of the increase in Contract price.
2. A copy of the revised Payment and Performance Bonds shall be provided by the Contractor to the Purchasing and Contracts Office within 14 calendar days of VRE's approval of such change. The Contractor shall execute change orders with the consent of the surety or sureties on the Payment and Performance Bond unless otherwise directed by the sureties. All such work shall be executed under the conditions of the original Contract, except that modification of the Time for Completion caused thereby shall be made at the time of approving such change.
3. Upon the Contractor's request, VRE may decrease bond amounts as deliverables are received.

C. Work may be invoiced for payment only once the Contractor possesses a fully executed Contract Amendment.**D. The Construction Manager is not authorized to approve Change Orders or authorize extra work without written concurrence of the VRE Contracting Officer.****1.05 VRE CHANGE ORDERS****A. VRE, without invalidating the Contract, may order extra Work or make changes by addition, deletion or revision in the Work, with the total Contract Amount being adjusted accordingly if applicable. Changes shall include:**

1. A detailed description of a proposed change,
2. Supplementary or revised drawings and specifications,

3. A change in Contract Time for executing the change work required,
 4. The period of time during which the requested price will be considered valid.
 5. Contractor will prepare and submit an estimate in a timely manner in order to not cause delay to the project schedule. VRE may further issue a directive to proceed with additional work under Time and Material basis.
- B. The Contractor shall review any VRE requested or directed change and shall respond in writing within 14 calendar days after receipt of the proposed change stating the effect of the proposed change upon Contractor's work, including any increase or decrease in Contract time and price. The Contractor shall furnish VRE an itemized breakdown of the quantities and prices used in computing the proposed change. The Contractor shall also furnish any sketches, drawings, and/or pictures to properly explain the change or impact to VRE. It is the sole responsibility of the Contractor to provide adequate change order backup to satisfy VRE.
1. The value of any such extra work or change shall be proposed by VRE in one or more of the following ways: (a) by estimate in a lump sum; (b) by cost and fixed fee; (c) by unit price additions or deletions of quantities stated in the Contract; or (d) any other method permitted under VRE's Procurement Manual.
 2. If none of the aforementioned methods is agreed upon the Contractor shall proceed with the work without delay under Time and Materials, provided the Contractor receives a Construction Change Directive. In such case, the Contractor shall keep and present in such form as the CM may direct, a correct account of the cost, together with vouchers. The CM shall be permitted to verify such records on a daily basis and may require such additional records as are necessary to determine the cost of the change to the Work. The CM shall include a firm Not-to-Exceed ceiling price that the Contractor may not exceed except at its own risk. A complete accounting of the extra cost shall be made within 14 days after completion of the work involved in the claim. Refer to Time and Materials (Force Account) Change Orders, below for a description of allowable costs when work is performed under force account.
- C. Once the scope, cost and schedule impacts, if any, are agreed upon, the CM will prepare the Change Order, possibly combining with other approved Change Orders, and submit to VRE for Processing. Approval may be contingent on funding agency or VRE Board authorization. Once processed, a Contract Amendment will be issued for signature by the Contractor. Once the Contract Amendment has been signed by the Contractor and VRE, it is considered executed. VRE may require additional bond protection as described above.

1.06 PREPARATION OF CONTRACTOR PROPOSED CHANGE ORDERS

- A. The Contractor may propose a change by submitting a Potential Change Order (PCO) commonly known as Request for Change (RFC) to the Construction Manager, describing the proposed change and its full effect on the Work, with a statement describing the reason for the change, the effect on the Contract Sum and Contract Time with full documentation and a statement describing the effect on Work by separate or other contractors.

- B. Contractor shall provide written notice of intent to claim additional cost or time within 14 days of their knowledge of such. Failure to do so will result in automatic rejection of claims.
- C. Submit a description of work that is considered beyond the scope of the contract for review and approval prior to start of work. VRE must be allowed sufficient time to review and make a determination of entitlement for additional compensation or time. The Contractor's submittal shall be in sufficient detail to enable VRE to determine the basis of entitlement.
- D. PCO must be signed and dated by the Contractor in order to be accepted by VRE.
- E. Failure to furnish sufficient documentation or to qualify their reason for failure to do so may delay the project. If such delay occurs, it will in no way relieve the Contractor of their obligation to meet the time limits or other requirements established for the contract or constitute basis for a delay claim on part of the Contractor.
- F. Maintain detailed records of related work performed, including photos if they help demonstrate the work. Provide complete information required for evaluation of proposed changes and to substantiate costs of changes in the Work.
- G. Document each quotation for a change in itemized cost or time with sufficient data to allow evaluation of the quotation. Provide itemized breakdown of cost.
- H. At a minimum, provide the following data and/or documentation to support computations:
 - 1. Quantities of products, labor, and equipment
 - 2. Insurance and bonds
 - 3. Overhead and profit
 - 4. Justification for any change in Contract Time and revision to project schedule to clearly identify critical path
 - 5. Credit for deletions from Contract, similarly documented
- I. Support each claim for additional costs, and for work performed under time and material basis, with additional information:
 - 1. Origin and date of claim
 - 2. Dates and times work was performed, and by whom reviewed and approved
 - 3. Time records and wage rates paid
 - 4. Invoices and receipts for products, equipment, and subcontracts, similarly documented
 - 5. Prior approval and signoff by VRE
- J. VRE shall review the Contractor initiated change and respond in writing as follows:
 - 1. Agree with Contractor's cost proposal;
 - 2. Request for additional information;

3. Reject the Proposal.
- K. If additional information is requested by VRE, Contractor shall respond in writing within fourteen (14) days of request.
- L. If the scope, cost, and schedule impacts, if any, are agreed upon, the PCO will be incorporated into a Change Order, possibly combined with other approved PCOs. The Change Order will be prepared by the CM with all required documentation from all included PCOs and submit to VRE for processing. Approval may be contingent on funding agency or VRE Board authorization. Once processed, a Contract Amendment will be issued for signature by the Contractor. Once the Contract Amendment has been signed by the Contractor and VRE, it is considered executed. VRE may require additional bond protection as described in paragraph above.

1.07 TERMS OF CHANGE ORDERS

A. Lump Sum Change Orders

1. Based on Proposal Request and Contractor's fixed price quotation or Contractor's request for a Change Order as approved by VRE.
2. A cost proposal for a change in the Work shall provide a complete breakdown itemizing the estimated quantities and costs of labor, materials, and equipment (base cost) required in addition to any markup used. The allowable percentage markups for overhead and profit for a change to the Work performed by the Contractor's own forces or performed by the Subcontractor shall not exceed the percentages for each category listed below.
 - a. Contractor's markup for overhead for work it performs in a change to the Work shall be ten percent (10%) of the Base Cost.
 - b. Subcontractor's markup for overhead for the work it performs in a change to the Work shall be a maximum of five percent (5%) of the Base Cost.
 - c. Contractor's markup for overhead for work performed by a Subcontractor in a change to the Work shall be a maximum of five percent (5%) of the Base Cost. The Contractor's 5% for overhead shall be calculated using the Base Cost only, and not calculated on top of the Subcontractor's overhead and profit.
 - d. The markup for overhead of a Sub-subcontractor at any tier on a change to the Work it performs shall be a maximum of five percent (5%). The Contractor's and all intervening tiers of Subcontractors' markup on such Sub-subcontractor's base cost in the change to the Work shall not exceed a total of five percent (5%).
 - e. Profit: The Contractor and sub-contractors shall be allowed up to a ten (10%) markup for profit on all properly documented and approved costs for all profit associated with labor costs. Where profit is a negotiated element of price, a reasonable profit will be negotiated considering factors such as, but not limited to:
 - i. Degree of Risk

- ii. Relative Difficulty of Work
 - iii. Size of Job
 - iv. Period of Performance
 - v. Subcontracting
- 3. Base Cost is defined as the total of labor, material, and equipment costs; it does not include markup for overhead and profit. The labor costs include only the costs of employees directly constructing or installing the change in the Work and exclude the costs of employees coordinating or managing the work.
 - 4. The allowable percentage markups for overhead and profit stated above shall compensate the Contractor, Subcontractor, and Sub-subcontractor(s) for all other costs associated with or relating to the change to the Work including by way of illustration and not limitation, general conditions, field supervision, field engineering, coordination, insurance, bond(s), use of small tools, incidental job costs, and all other general and administrative home and field office expenses.
 - 5. Allowable costs for changes in the Work shall not include Home Office expenses including payroll costs for the Contractor's officers, executives, administrators, project managers, estimators, clerks, timekeepers, and other administrative personnel employed by the Contractor, whether at the Site or in the Contractor's principal or branch office for general administration of the Work. These costs are deemed overhead included in the percentage markups in Subsection (B) above.

B. Unit Price Change Orders

- 1. This subsection only applies to Unit Price contracts.
- 2. For pre-determined unit prices and quantities, the Change Order will be executed on a fixed unit price basis. VRE may elect to negotiate unit price based on revised item quantity.
- 3. Overrun of estimated quantities will only be allowed as approved by VRE. See Section 01 22 00, "Unit Prices," for additional details regarding payment for unit price items and overrun of quantities. Contractor shall notify VRE, prior to performing the work, in writing for work that may occur beyond the item quantity provided in the contract.
- 4. Confirm in-place quantities with the field representative on a daily basis as work is completed. Unless otherwise noted, work will be paid for based on in place quantities.
- 5. For items which do not have unit prices pre-determined by the Contract, a PCO must be submitted in accordance with the requirements in this Section. New unit price items included in the PCO shall contain all labor, materials, and equipment necessary to perform the Work in accordance with the Contract Documents. The Contractor's and Subcontractor's overhead and profit, as defined above, shall be included in these unit prices.

C. Time and Material Change Orders

1. Should circumstances dictate that changed work be started immediately, VRE may direct the Contractor to proceed with the work on a Time and Material (T&M) basis pending a contract modification. T&M Change Orders may be used at VRE's discretion and only when either:
 - a. Agreement on the valuation of a change cannot be made using the methods described in the preceding paragraphs; or
 - b. VRE cannot firmly establish an applicable and estimate for the cost of the work because the level of effort necessary to perform and complete the work cannot be reasonably estimated or anticipated but can only be determined by performing the work.
2. Because of the significant burden on VRE to monitor and control the work, T&M work is not a preferred method, and it shall be the responsibility of the Contractor to provide all necessary documentation and justification of costs. The rates for labor, equipment and materials to be used in cases of work performed on a T&M basis will be compensated as documented below. No costs other than those explicitly listed below shall be allowed.
3. T&M contracts are only to be used after a documented determination that no other type of contract is suitable. When issuing a T&M change order, VRE shall include a firm Not-to-Exceed (NTE) ceiling price that the Contractor may not exceed except at its own risk.
4. Upon request, VRE may require Contractor to submit an estimate of cost and time impacts on Time and Material work prior to authorizing the work.
5. Contractor shall maintain detailed records of work performed on Time and Material basis. Confirm in-place quantities with the field representative on a daily basis as work is completed. Unless otherwise noted, work will be paid for based on in place quantities. Review Time and Material records with the field representative to obtain daily agreed upon quantities.
 - a. As the Work progresses, the Contractor is to monitor its costs. If their costs will exceed the NTE prior to completing the work, the Contractor is to stop work and notify the CM. A decision will be made by VRE to stop the change at the time or to authorize an increase in the NTE amount.
6. The Contractor is not to proceed with the Work until a written T&M directive has been signed by the Contractor and VRE.
7. The Contractor shall be paid for all labor, materials, equipment, services, supplies, taxes, overhead, profit, and miscellaneous costs or expenses for extra work performed on a Time and Materials basis in the following manner:
 - a. **Labor:** Labor costs shall be composed of direct labor cost plus labor burdens. Before any T&M work begins, the Contractor shall submit for approval to the CM the

proposed hourly rates and associated labor costs (benefits and payroll burden) for all laborers and forepersons to be engaged in the work. The number of laborers and forepersons engaged in the work will be subject to approval by the CM as justified by the nature of the work. For all labor and forepersons in direct charge of the T&M work, excluding general superintendence, compensation as listed below. Direct labor cost shall not be higher than those regularly paid the employee. The Contractor shall provide certified payroll records for audit purposes.

- i. **Certified Pay Rate:** Unless otherwise approved, the Contractor will receive the actual rate of wage or scale as set forth in their most recent payroll for each classification of laborers, and forepersons who are in direct charge of the specific operation. The time allowed for payment will be the number of hours such workers are actually engaged in the work. If overtime work is authorized by VRE, payment will be at the normal overtime rate set forth in the Contractor's most recent payroll. If workers performing the class of labor needed have not been employed on the project, mutually agreed on rates will be established. However, the rates shall be not less than those predetermined for the project, if applicable.
- ii. **Benefits:** The Contractor will be entitled to receive the actual cost for any fringe benefits that are regularly provided to the classes of laborers and forepersons engaged in the work and that are not included in the certified pay rate.
- iii. **Payroll Burden:** The Contractor will be entitled to receive the actual cost for all costs associated with required payroll taxes and payroll benefits not covered in the previous paragraph including:
 1. Social Security Tax
 2. Medicare Tax
 3. Unemployment Tax
 4. Worker's Compensation Insurance
 5. Contractor's Public Liability Insurance
 6. Contractor's Property Damage Liability Insurance

If the Contractor is unable to provide the necessary documentation for Benefits and Payroll Burden as identified above, the Contractor will be entitled to an additive of 20% of the Certified Hourly Pay Rate as full and final compensation for Benefits and Payroll Burdens.

- iv. **Overhead:** The Contractor shall be entitled to an additive of ten (10%) on all properly documented and approved costs established in paragraphs i, ii, and iii for all administrative overhead associated with labor costs.
- v. **Profit:** The Contractor shall be allowed up to a ten (10%) markup for profit on all properly documented and approved costs established in paragraphs i, ii, iii and iv

above for all profit associated with labor costs. Where profit is a negotiated element of price, a reasonable profit will be negotiated taking into account factors such as, but not limited to:

1. Degree of Risk
2. Relative Difficulty of Work
3. Size of Job
4. Period of Performance
5. Subcontracting

- b. **Materials:** The Contractor will receive the actual cost of materials accepted by VRE that are delivered and used for the work including taxes, transportation, and handling charges paid by the Contractor, not including labor and equipment rentals as herein set forth. The Contractor shall make every reasonable effort to take advantage of trade discounts offered by material suppliers. Any discount received shall pass through to the VRE. The appropriate salvage value of salvageable temporary construction materials shall be credited to VRE.
 - i. Vendor's and/or supplier's invoices accompanied by evidence of payment shall be provided to the CM to establish the Contractor's cost of materials. Payment will only be made for the material consumed during the performance of the Time & Material Work or for approved material which is incorporated as part of the finished work.
- c. **Equipment:** The Contractor shall provide VRE a list of all equipment to be used in the work. For each piece of equipment, the list shall include the serial number; date of manufacture; location from which equipment will be transported; and, for rental equipment, the rental rate, and name of the company from which it is rented. The number and types of equipment engaged in the work will be subject to approval by the CM as justified by the nature of the Work. Compensation for equipment shall be as follows:
 - i. **Hourly Base Equipment Rental Rates (Owned Equipment):** For machinery, equipment, and attachments, necessary for prosecution of the work that are owned by the Contractor and approved for use by VRE, the Contractor will be paid an Hourly Base Rental Rate as detailed in the following paragraphs.
 1. **Equipment referenced in "Rental Rate Blue Book for Construction Equipment":** Equipment rental will be measured by time in hours of actual time engaged in the performance of the work and necessary traveling time of the equipment within the limits of the project or source of supply and the project. Hourly rates will not exceed 1/176 of the monthly rates of the schedule shown in the "Rental Rate Blue Book" modified in accordance with the "Rental Rate Blue Book" rate adjustment tables that are current at the time the

Time and Materials work is authorized. Equipment rental rates not modified by the adjustment factors or rate modifications indicated in the “Rental Rate Blue Book” will not be considered unless submitted by the Contractor and approved by VRE.

2. **Equipment not referenced in “Rental Rate Blue Book for Construction Equipment”:** The rates for equipment not listed in the *Rental Rate Blue Book* schedule, a monthly rental rate may be computed on the basis of an amount that is equivalent of 6 percent of the manufacturer’s list price of the sale (new) of such equipment. The hourly rate in such cases may be determined by dividing the monthly rate by 176 when actually operating.
- ii. **Hourly Base Equipment Rental Rates (Rented Equipment):** If the Contractor does not possess or have readily available equipment necessary for performing the T&M work and such equipment is rented from a source other than a company that is an affiliate of the Contractor, payment will be based on actual invoice rates when the rates are reasonably in line with established rental rates for the equipment in question and are approved by the CM.
- iii. **Hourly Operating Rates:** – Hourly Operating Rates shall be as established in the Blue Book estimated operating cost per hour. This operating cost will be full compensation for fuel, lubricants, repairs, servicing (greasing, fueling, and oiling), small tools, and any and all incidentals. If rental rates for the equipment being used in the work are not listed in the Blue Book or otherwise readily available, the Hourly Operating Cost will be 15% of the established Hourly Base Rental Rate. If invoices for Rental Equipment include the furnishing of fuel, lubricants, repair, and servicing, then the Contractor will not be entitled to any Hourly Operating costs for that equipment.
- iv. **Equipment Usage:** An amount, as described above, will be paid for all hours the equipment is engaged in performing the work. The Contractor shall be entitled to the applicable Hourly Base Equipment Rental Rate and Hourly Operating Rate for all approved equipment usage. No compensation will be paid for the use of machinery or equipment not authorized by VRE.
- v. **Equipment Standby:** For the purposes herein “standby time” is defined as the period of time equipment ordered to the jobsite by VRE is available on-site for the work but is idle for reasons not the fault of the Contractor or normally associated with the efficient and necessary use of that equipment in the overall operation of the work at hand. Hourly rates for equipment on standby will be at 50 percent (50%) of the rate paid for equipment performing work. Operating costs shall not be included in the standby rate.
- vi. Payment will be made for the total hours the equipment is performing work. When equipment is performing work less than 40 hours for any given week and is on standby, payment for standby time will be allowed for up to 40 hours, minus hours

performing work. Payment for Standby will be allowed only for working days. Payment will not be made for the time that equipment is on the project in excess of 24 hours prior to its actual performance in the Time and Materials work.

- d. **Transportation Costs:** When it is necessary to obtain equipment exclusively for T&M work from sources beyond the Project limits and the CM authorizes the transporting of such equipment to the Project site, the cost of transporting the equipment will be allowed as an expense. The Contractor will be paid freight cost covering the moving of equipment to and from the specific Time and Materials operation provided such cost is supported by an invoice showing the actual cost to the Contractor.
 - i. Where the transport requires the use for a hauling unit, the allowable expense will consist only of the actual cost incurred for the use of the hauling equipment, or the applicable Blue Book cost, whichever is less.
 - ii. When equipment is transferred under its own power, the allowable Transporting cost shall be 50% of the Hourly Base Equipment Rental Rate.

However, such payment will be limited to transportation from the nearest source of available equipment. If equipment is not returned to the nearest equipment storage lot but is moved to another location, the freight cost paid will not exceed the cost of return to the nearest storage lot.

- e. **Compensation:** The compensation as set forth in this Section shall be accepted by the Contractor as payment in full for work performed on a Time and Materials basis. At the end of each day, the Contractor's representative and the Inspector shall compare and reconcile records of the hours of work and equipment, labor and materials used in the work as ordered on a Time and Materials basis. Such accounting may not include actual costs or labor rates where these are not available but shall be used to verify quantities, types of materials or labor, and number and types of equipment. No compensation will be allowed for equipment which is inoperable due to mechanical failure.
- f. **Overhead:** The Contractor shall be entitled to an additive of up to ten percent (10%) on all appropriate and approved Equipment Rental, Operating, and Transporting costs as defined above.
- g. **Profit:** The Contractor shall be allowed up to a ten (10%) markup for profit on all properly documented and approved Equipment Rental, Operating, and Transporting costs as defined above. Where profit is a negotiated element of price, a reasonable profit will be negotiated taking into account factors such as, but not limited to:
 - i. Degree of Risk
 - ii. Relative Difficulty of Work
 - iii. Size of Job

- iv. Period of Performance
- v. Subcontracting
- h. **Meals and Lodging Allowance:** Meals and lodging allowance may be allowed by the CM at the actual and documented costs for lodging and meals if the following conditions are met and the applicable rates and authorization for such costs are established prior to beginning the work. No additives for overhead, administrative, profit, or any other costs will be permitted for subsistence and lodging.
 - i. The specific T&M work requires mobilization of a separate crew not intended to be used on the original contract, and the Contractor's base location is more than 50 miles from the work site, or
 - ii. Forces which have been working on the Contract will be used for the T&M work and have been routinely staying overnight during the life of the Project, and the T&M work will warrant an extension of the contract time, and the distance from the Contractor's base location to the work site is more than 50 miles.
- i. **Miscellaneous:** No additional allowance will be made for attachments that are common accessories for equipment as defined in the Rental Rate Blue Book, general superintendents, timekeepers and secretaries, or other costs for which no specific allowance is herein provided.
 - i. Small Tools: No payment will be made for the use of small hand-held tools. Small tools are defined as any individual piece of equipment or tools having a new value \$1,000 or less.
 - ii. Insurance and Bonds: The Contractor will receive compensation equal to the cost of the bond, special railroad insurance premiums, and other additional costs necessary for the specific Time and Materials work as determined by the VRE. The Contractor shall supply documented evidence of such costs.
- j. **Subcontracting:** If all or a portion of the Time and Materials work is performed by an approved subcontractor, the sub-contractor shall receive the cost of work performed as determined in (a through i) above. In addition, the Contractor will be paid up to 10 percent of the subcontract net Time and Materials costs to cover the Contractor's profit and administrative cost per the schedule below.

Total Cost of Subcontract Work: Rate Schedule

\$0 - \$10,000	10%
>\$10,000	\$1,000 + 5% above \$10,000

The amount resulting will not be subject to any further additives. The itemized statements of costs as required below shall be submitted on a form that separates the subcontracted portions of the Time and Materials labor, materials, and equipment from the other Time and Materials costs.

- k. **Statements:** Payments will not be made for work performed on a Time and Materials basis until the Contractor has furnished VRE duplicate itemized statements of the cost of such work detailed as follows:
 - i. Payroll indicating name, classification, date, daily hours, total hours, rate, and extension of each laborer, foreperson. Contractor's superintendent and/or Project Manager shall not be included.
 - ii. Designation, dates, daily hours, total hours, rental rate, and extension for each unit of equipment.
 - iii. Quantities of materials, prices and extensions.
 - iv. Transportation of materials.
 - v. Statements shall be accompanied and supported by invoices for all materials used and transportation charges. However, if materials used on the T&M work are not specifically purchased for such work but are taken from the Contractor's stock, then in lieu of the invoices, the Contractor shall furnish an affidavit certifying that such materials were taken from their stock; that the quantity claimed was actually used; and that the price, transportation, and handling claimed represented their actual cost.
- 8. Provide documentation for overall project schedule impacts in the form of Gantt Chart with clearly identified critical path items.
- 9. Time and Materials work will be included in a subsequent Change Order.

1.08 CONTRACT TIME EXTENSIONS

A. Time Extensions Due to Weather Events

VRE may give consideration for extension of time when a delay occurs due to unforeseen causes beyond the control of or without the fault or negligence of the Contractor. However, consideration will not be given to extensions of time attributable to normal adverse weather conditions or conditions resulting from normal adverse weather. For the purposes of this Section, normal adverse weather is defined as that which is not considered extraordinary or catastrophic and is not reasonably conducive to the Contractor progressively prosecuting critical path work under the Contract. Weather events considered extraordinary or catastrophic include, but are not limited to, tornados, hurricanes, earthquakes, and floods that exceed a 25-year storm event as defined by National Oceanic and Atmospheric Administration (NOAA) for the NOAA data gathering location that is nearest the project site. The Contractor shall make the request within the written PCO in accordance with the applicable portions of this Section and 01 32 00 "Construction Progress Documentation."

B. Time Extensions Due to Additional Work

If the Contractor believes a particular scope of work associated with a PCO warrants a Contract time extension, the Contractor shall make the request within the written PCO in accordance

with the applicable portions of this Section. The Contractor shall provide written supporting data for any request for extension of time due to additional Work.

The written supporting data shall include the particular construction operations affected, their criticality to project milestones or overall Contract completion, and the significant dates that encompass the period of the requested time extension. The Contractor shall furnish any additional information requested by the CM or VRE as necessary for VRE to make an adequate evaluation of the request.

1.09 CHANGE ORDERS FOR COMPENSABLE DELAY

- A. The Contractor may be entitled to compensation for a compensable delay. Compensable delays are critical delays that are not the Contractor's fault or responsibility and are VRE's fault or responsibility. The Contractor shall prepare and submit documentation and request for any such Change Order for review by the CM and VRE. Compensation may include extension of Contract term and not necessarily payment. Compensable delays may include, but are not limited to:
 - 1. Delays due to alteration of quantities or character of work
 - 2. Delays due to differing site conditions
 - 3. Delays due to a VRE-ordered suspension not prompted by Contractor actions
 - 4. Delays due to the acts or omissions of VRE or its failure to act in a timely manner
- B. The following delays are not compensable:
 - 1. Acts or omissions of the Contractor, its agents, employees, subcontractors or suppliers or causes within their control or conditions that the Contractor could reasonably have foreseen or avoided
 - 2. Floods, tidal waves, tornadoes, hurricanes, lightning strikes, earthquakes, fires, epidemics, or similar natural phenomena
 - 3. Normal adverse weather
 - 4. Extraordinary, unforeseen, and unavoidable delays in material deliveries
 - 5. Acts of government entities other than VRE
 - 6. Unforeseen and unavoidable industry-wide labor strikes affecting the Contractor or its subcontractors' or suppliers' workforce that are beyond the Contractor's control
 - 7. Actions of third parties that are not the responsibility of the Contractor or within its or VRE's control
 - 8. Civil disturbances or sovereign acts of the State, including but are not limited to states of emergency or epidemic or quarantine restrictions
 - 9. Time period following Notice of Award to the Contractor and prior to Notice to Proceed to the Contractor

- C. If Contractor requests compensable delays or an extension to the Time for Completion due to changes in the Work it must provide to the CM adequate documentation substantiating its entitlement for the time extension. The documentation must demonstrate an anticipated actual increase in the time required to complete the Work beyond that allowed by the Contract as adjusted by prior changes to the Work, not just an increase or decrease in the time needed to complete a portion of the total Work.
- D. No extension to the Time for Completion or compensable delay shall be granted unless the additional or change to the Work increases the length of the critical path beyond the Time for Completion as demonstrated on the approved CPM schedule or bar chart schedule. Any Float belongs to VRE. A written statement in addition to an Impact Analysis Schedule shall be prepared explaining how no other sequence of work activities could have been performed to decrease the impact or eliminate the impact altogether. If requested by the CM the Contractor must provide alternate documentation detailing the claim to VRE's satisfaction
- E. To request payment for a compensable delay, the Contractor shall within 14 days after the end date of a delay event, unless directed otherwise in writing by VRE, submit a written PCO to the CM, for review and approval. With the request, the Contractor shall submit an Impact Analysis Schedule and all supporting data to objectively substantiate its request. VRE will evaluate the Contractor's Impact Analysis Schedule and all supporting data to determine entitlement and the appropriate amount of compensation, according to the following Site direct overhead expenses:
 - 1. Field Office Overhead (FOOH)
 - a. FOOH is the extended project field office overhead and site costs and expenses that are not attributable to specific Contract pay items, but are incurred in support of the project as a result of a delay, which include:
 - i. Extended site supervision costs such as salaries for project field superintendent and administrative staff.
 - ii. Extended site office costs such as utilities (heat, electricity, water, heat, etc.), trailers, field office, office equipment, and sanitary and toilet facilities.
 - iii. Extended site costs that are not used for specific Contract pay items.
 - b. All other direct and indirect overhead expenses are considered covered by and included in Section 1.07 above. In no case shall subcontractor extended overhead be submitted or considered. VRE does not have a direct contractual relationship with any subcontractor or supplier and therefore will not direct, discuss or negotiate with subcontractors employed by the Contractor.
 - c. The Contractor is entitled to FOOH only for compensable delays for which VRE has granted a Contract time extension. The Contractor is not entitled to additional compensation for FOOH for delays that are caused by extra work performed on a Force Account (Time and Materials) basis or for increased quantities.

- d. The Contractor's agreed amount of compensation for FOOH shall be based on the project daily FOOH rate derived from the Contractor's Itemized Project FOOH Costs set out on VRE's form or other format acceptable to VRE. The Contractor shall submit the form to VRE no later than 30 days after the Notice to Proceed date or on a date approved by VRE. On the form, the Contractor shall list each project FOOH item, the total estimated costs or expenses for each FOOH item for the original Contract time, the total project FOOH, and the project daily FOOH rate based on the total project FOOH divided by the original Contract duration. The compensation for FOOH will be calculated as follows:

$$\begin{aligned} &(\text{Daily FOOH Rate}) \times (\text{No. of Days of Compensable Delay}) = \\ &(\text{Amount of FOOH}) \end{aligned}$$

2. Home Office Overhead (HOOH)

- a. HOOH is the Contractor's allowable home office overhead costs and expenses that cannot be attributed and are not billed to a particular project but are incurred in support of all of the Contractor's projects, including but not limited to rent, office equipment and furnishings, insurance, office supplies, depreciation, taxes, and utilities, as well as executive salaries, administrative, staff salaries, project support staff salaries, and accounting and payroll services.
- b. The Contractor is entitled to payment of HOOH only for compensable delays for which VRE has granted a Contract time extension and only when the Contractor could not reasonably recoup its HOOH while its workforce was idled by the delay because the Contractor was required to remain on standby, ready to resume work, and unable to perform other work at the project or elsewhere during the delay.
- c. The Contractor is not entitled to compensation for HOOH for delays that are caused by extra work performed on a Force Account basis or by increased quantities.
- d. The agreed amount of compensation for extended or unabsorbed HOOH for a compensable delay will be determined as follows:

$$(A \times C) / B = D \text{ and } D \times E = F$$

Where:

A = Original total Contract amount

B = Original Contract duration (number of calendar days between and inclusive of the Contract Notice to Proceed (NTP) date and the original Contract Completion Date)

C = 6% (Agreed allowable HOOH percentage)

D = Daily allowable HOOH rate

E = Number of days of compensable delay

F = Agreed amount of compensation for HOOH

- e. In no case shall subcontractor extended overhead be submitted or considered. VRE does not have a direct contractual relationship with any subcontractor or supplier and therefore will not direct, discuss or negotiate with subcontractors employed by the Contractor.
3. When to Audit to Determine FOOH and HOOH
- a. The Contractor may propose a higher rate determined according to Federal Acquisition Regulations 48 CFR § 31 or other accounting standard if the Contractor determines that the agreed allowable HOOH percentage is insufficient.
 - b. The Itemized Project FOOH Costs (IPFC) and FOOH shall be subject to field verification and VRE audit, at any time, as determined by VRE, if VRE determines that the rate the Contractor submits is not an accurate representation of the Contractor's actual FOOH at the time of occurrence of the delay. If VRE determines the daily FOOH rate is not an accurate representation of the Contractor's actual FOOH, the Contractor shall submit its actual project FOOH records at the time of occurrence of the delay, as requested by VRE. VRE may perform an audit of the Contractor's records as necessary to verify the Contractor's actual project FOOH. Adjustments to the daily FOOH rate may be made upon verification or VRE audit of the Contractor's actual project FOOH. The project daily FOOH rate will then be calculated utilizing the rate determined by the audit. VRE may also elect to perform an audit of the Contractor's actual project FOOH at the completion of the Contract, as determined by VRE, in which case the project FOOH paid previously by change order may be adjusted based on the rate determined by the audit.
 - c. The Contractor's actual extended FOOH are defined to be those costs and expenses incurred from the original Contract time limit to the actual final acceptance of the project as documented by timesheets, payroll records, accounting records, contracts, invoices, bills, receipts, tickets, cancelled checks, and similar business records showing the costs and expenses actually incurred for the project field supervision and administrative staff, project field office, and overhead items submitted in accordance with this provision; and the records must be accurate and auditable.
 - d. If the total sum of the extended project FOOH and unabsorbed or extended HOOH for all approved change orders exceeds 20 percent of the original Contract amount, VRE may at its option calculate the amount of FOOH and HOOH based on a VRE audit of the Contractor's actual project FOOH and HOOH records. In such event, VRE will perform the audit according to Section 103.08 at VRE's expense. The VRE audit may

begin on 10-days notice to the Contractor, its subcontractors, and suppliers. The Contractor, subcontractors, and suppliers shall make a good faith effort to cooperate with the auditors.

1.10 DIFFERING SITE CONDITIONS

- A. VRE recognizes two types of Differing Site Conditions as defined below. Contractor is responsible for identifying the presumed type of differing site conditions when submitting a request for change. The type of differing site conditions shall be confirmed by the CM.

1. Type I

During the progress of the Work, if subsurface or latent physical conditions differing materially from those indicated in the Contract are encountered at the site, the Contractor shall promptly notify VRE in writing of the specific differing conditions before the site is disturbed further and before the affected work is performed.

2. Type II

During the progress of the Work, if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site the Contractor shall promptly notify VRE in writing of the specific differing conditions before the site is disturbed further and before the affected work is performed.

- B. Upon receipt of such written notification, VRE will acknowledge receipt and investigate the conditions. If it is determined by VRE that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an equitable adjustment, excluding anticipated profits, will be made and the Contract may be modified in writing accordingly. VRE will notify the Contractor of the determination whether or not an equitable adjustment of the Contract is warranted.

No equitable adjustment that results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

1.11 PAYMENT FOR CONTRACT AMENDMENT WORK

- A. Revise Schedule of Values and Application for Payment forms to record each executed Contract Amendment as a separate category. Further define line items within each Contract Amendment category exactly as defined in the executed Contract Amendment and adjust the Contract Sum as shown on the Contract Amendment. Submit the revised Schedule of Values and related forms with the next Application for Payment following execution of the Contract Amendment.
- B. Revise progress schedules to reflect any change in Contract time, revise sub-schedules to adjust time for other items of work affected by the change. Submit the revised schedules on the next previously agreed upon submittal date following execution of the Contract Amendment.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 29 00**Payment Procedures****PART 1 - GENERAL****1.01 SUMMARY**

The Section includes administrative and procedural requirements necessary to prepare and process Applications for Payment. Sub-sections include:

- A. Submittal Procedures
- B. Preparation of Application for Payment
- C. Supporting Documentation
- D. Payment for Mobilization
- E. Payment for Stored Materials
- F. Certified Payroll Records
- G. Application for Payment at Substantial Completion
- H. Final Application for Payment

1.02 RELATED SECTIONS

- A. General Provisions
- B. Special Provisions
- C. Section 01 22 00- Unit Prices
- D. Section 01 32 00- Construction Progress Documentation
- E. Section 01 77 00 – Closeout Procedures

1.03 DEFINITIONS

- A. **Schedule of Values:** A statement furnished by the Contractor allocating portions of the Contract Price to various portions of the Work and once accepted, to be used as the basis for reviewing the Contractor's Applications for Payment. In the event of a Unit Price Contract, the Schedule of Values shall contain pay items exactly as described in section 1.04 below.

1.04 SUBMITTALS**A. Coordination**

- 1. Coordinate preparation of the Schedule of Values with preparation of the Contractor's Construction Schedule.

B. Schedule of Values

- 1. Submit draft Schedule of Values to the Construction Manager for review and approval within 7 days following Notice to Proceed. The Schedule of Values shall be organized to the satisfaction of VRE so that line items contain specific areas of work based on physical

location and what can be visually verified by the Contractor and the CM. Acceptance of the Schedule of Values shall not forfeit VRE's right to require substantiating data to verify the value of work delivered prior to processing payments.

2. Submit final approved Schedule of Values prior to submittal of first progress payment.
3. Provide a breakdown of the Contract Price in enough detail to facilitate continued evaluation of Applications for Payment and progress reports. Provide line items for principal subcontract amounts, where applicable. The value assigned to the total of the following line items, if applicable, shall be five percent (5%) of the Contract Price:
 - a. Testing and Commissioning Activities
 - b. Operation and Maintenance Manuals
 - c. Punch List Activities
 - d. Project Record Documents
 - e. Bonds and Warranties
 - f. Demonstration and Training
4. Round amounts to the nearest whole dollar. Total shall equal the Contract Price.
5. Provide separate line items in the Schedule of Values for initial cost of materials, for each subsequent stage of completion and for total installed value of that part of the Work.
6. Each item in the Schedule of Values and Application for Payment shall be complete. Include total cost and proportionate share of general overhead and profit for each item.
7. VRE may elect to provide the Contractor with a Schedule of Values format based on the proposed construction and / or Pay Items, detailing the breakdown of payment for Work desired by VRE. If provided, the Contractor shall utilize the VRE format and fill in the cost for each line item. The draft with the costs included shall be returned to the CM for approval prior to the first monthly Application for Payment.
8. In the event of a Unit Price Contract, the Schedule of Values shall contain, at a minimum, all pay items exactly as shown on the Contractor's accepted bid sheet, part of the Agreement with VRE. Schedule of values shall incorporate the items 1-7 listed above.

C. Schedule Updating

Update and resubmit the Schedule of Values with the next Application for Payment when Contract Modifications result in a change in the Contract Price.

1.05 PREPARATION OF APPLICATION FOR PAYMENT

- A. Each Application for Payment shall be consistent with previous applications and payments as paid by VRE.
- B. Format shall be AIA G702 (Application and Certificate for Payment) & AIA G703 (Continuation Sheet). The Schedule of Values shall be identical to the approved draft Schedule of Values.

- C. The payment period shall be based on the calendar month, starts on the day following the end of the preceding period and shall not exceed one calendar month, unless otherwise approved by the CM. Application for Payment shall coincide with CPM schedule monthly update or as otherwise indicated in the Agreement with VRE and the Contractor. Maintain payment schedule throughout duration of project.
- D. Five percent (5%) of monthly progress payments will be held as retainage by VRE.
- E. Application for Payment shall match data on the Schedule of Values and Contractor's Construction Schedule. Use updated schedules if revisions were made.
- F. List each authorized Contract Amendment as an extension on the continuation sheet, listing the Contract Amendment number, a brief description, and the dollar amount as for an original item of Work. Break down Contract Amendment totals into separate line items as they are shown in the Contract Amendment to track separate work activities. Only include amounts of Contract Amendments issued before the last day of the construction period covered by the application.
- G. Each month, the Contractor shall prepare a draft Application for Payment and submit electronically to the CM for preliminary approval. The Contractor is not required to have draft version signed or notarized, but it must contain all supporting documentation. The draft Application for Payment will be returned and not reviewed by the CM if it is not accompanied by all required supporting documentation, which may result in delay of payment.
- H. The draft Application for Payment shall include a transmittal or cover letter, listing all documents attached to the Application submitted for preliminary approval by the CM.
- I. Submit the draft Application for Payment to the CM no later than the 10th calendar day of the following month.
- J. Preliminary approval by the CM does not guarantee approval for payment by VRE.
- K. Once preliminary approval is provided by the CM, the Contractor shall prepare the signed and notarized Application for Payment, including attachments such as release of liens or affidavit of payments, as required by VRE. The Application must be executed by notarized signature of the Contractor's authorized officer. Application for Payment with original signatures and attachments shall be submitted directly to the VRE Project Manager (PM) for final review, approval, and payment. One (1) electronic copy (.pdf format) of the Application for Payment with signatures and attachments shall be submitted to the CM for record.

1.06 SUPPORTING DOCUMENTATION

The following supporting documentation must be included with each Application for Payment or submitted separately prior to the Application for Payment:

1. Monthly CPM Schedule Update
2. Certified Payroll Records
3. Contractor Daily Construction Reports
4. Contractor Monthly Construction Reports
5. Monthly Safety Report (can be combined with item 4 above)

6. Monthly Construction Photographs
7. Delivery Tickets for Permanent Materials
8. Inventory Statement and evidence of payment for on-site Stored Materials, if such reimbursement is being requested
9. Subcontractor Payment Form
10. Update of Construction Progress Documentation listed in other sections of Division 1 (i.e. 01 32 00, 01 35 23)
11. Other Contract deliverables to be submitted on a monthly basis, as requested by the CM or VRE

1.07 PAYMENT FOR MOBILIZATION

- A. Mobilization consists of performing preliminary operations, including moving personnel and equipment to the project site; paying bonds and insurance premiums; and establishing the Contractor's offices, buildings, and other facilities necessary to allow work to begin on a substantial phase of the Contract.
- B. Mobilization will be paid for at the contract lump sum price for this pay item. This price shall include demobilization.
- C. Payment for mobilization will be made in two separate installments. The first installment of 50 percent of the contract lump sum price pay item will be made on the first monthly Application for Payment following partial mobilization and initiation of construction work. The second installment will be made on the next monthly Application for Payment following completion of substantial mobilization, including erection of the Contractor's offices and buildings. Completion of erection of processing plants, if any, will not be required as a condition for the release of the second installment.
 1. The value assigned to Mobilization shall be as follows:

a. \$0 - \$200,000	10% of Total Contract Amount
b. \$200,000 - \$1,000,000	\$20,000 plus 7.5% (of total contract amount minus \$200,000)
c. Greater than \$1,000,000	\$80,000 plus 5% (of Total Contract Amount minus \$1,000,000)
- D. No additional payment will be made for demobilization and remobilization because of shutdowns, suspensions of work, or other mobilization activities.
- E. The Contractor may not submit their first monthly Application for Payment until the end of the first calendar month after receiving Notice to Proceed from VRE and mobilized to the project.

1.08 PAYMENT FOR STORED MATERIALS

- A. When requested in writing by the Contractor, partial payment allowances may be made for materials secured for use on the project and required to complete the project. Such material payments will be made for only those actual quantities of materials identified in the Contract,

Drawings, Specifications, executed Contract Amendments, or otherwise authorized and documented by the CM based on delivery tickets, bills of lading, or paid invoices. Materials shall be delivered to acceptable sites where the work is being performed or at other sites in the vicinity that are acceptable to VRE.

Such delivered costs of stored or stockpiled materials may be included in the next payment application after the following conditions are met:

1. CM accepts the manner in which the material has been stored at or on an approved site.
2. Contractor provides the CM with acceptable evidence of quantity and quality of the materials.
3. Contractor provides the CM with acceptable evidence that the material and transportation costs have been paid.
4. Contractor provides VRE legal title, free of lines or encumbrances of any kind, to the material so store and stockpiled.
5. Contractor provides VRE evidence that the material so stored or stockpiled is insured or bonded against loss by damage to or disappearance of such materials at any time before use in Work.
6. Contractor provides VRE with manufacturer's installation and maintenance information.

Such payments will only be made for materials scheduled for incorporation into the work within ninety (90) days.

- B. It is understood and agreed that the transfer of title and VRE's payment for such stored or stockpiled materials shall in no way relieve the Contractor of responsibilities for furnishing and placing such materials according to the requirements of the Contract Documents.
- C. In no case will the amount of payments of materials on hand exceed the Contract price for the materials or the Contract price for the Contract item in which the material is intended to be used.
- D. Contractor bears all costs associated with the payment for stored or stockpiled materials according to this Section.

Additionally, all payments shall be in accordance with the following terms and conditions:

E. Structural Steel or Reinforcing Steel

An allowance of 100 percent of the cost to the Contractor for structural steel or reinforcing steel materials secured for fabrication not to exceed 60 percent of the Contract price may be made when such material is delivered to the fabricator and has been adequately identified for exclusive use on the project. The provisions of this section for steel reinforcement will only apply where the quantity of steel reinforcement is identified as a separate and distinct bid item for payment.

An allowance of 100 percent of the cost to the Contractor for structural steel and reinforcing steel, not to exceed 90 percent of the Contract price, may be made when fabrication is

complete. Prior to the granting of such allowances, the materials and fabricated units shall have been tested or certified and found acceptable to the CM and shall have been stored in accordance with the requirements specified herein. Allowances will be based on invoices, bills, or the estimated value as approved by the CM and will be subject to the retainage requirements noted in Subsection 1.05.D above. For the purposes of this section, fabrication is defined as any manufacturing process such as bending, forming, welding, cutting, or coating with paint or anti-corrosive materials which alters, converts, or changes raw material for its use in the permanent finished work.

F. Other Materials

For aggregate, pipe, guardrail, signs, sign assemblies, and other nonperishable material, an allowance of 100 percent of the cost to the Contractor for materials, not to exceed 90 percent of the Contract price, may be made when such material is delivered to the project and stockpiled or stored in accordance with the requirements specified herein. Prior to the granting of such allowances, the material shall have been tested and found acceptable to the CM. Allowances will be based on invoices, bills, or the estimated value of the material as approved by the CM and will be subject to the retainage requirements noted in Subsection 1.05.D above.

G. Excluded Items

No allowance will be made for fuels, form lumber, falsework, temporary structures, or other work that will not become an integral part of the finished construction. Additionally, no allowance will be made for perishable material such as cement, seed, plants, or fertilizer.

H. Storage

Contractor shall deliver, store and handle materials using means and methods that will prevent damage, deterioration, theft and other losses. Material for which payment allowance is requested shall be stored in an approved manner in areas where damage is not likely to occur. VRE accepts no responsibility for materials stored on or off site.

If any of the stored materials are lost or become damaged, the Contractor shall repair or replace them at no additional cost to VRE. This damage can be, but not limited to, weather, oxidization, mold, mildew, warping and rust. Repair or replacement of such material will not be considered the basis for any extension of Contract time. If payment allowance has been made prior to such damage or loss, the amount so allowed or a proportionate part thereof will be deducted from the next monthly Application for Payment and withheld until satisfactory repair or replacement has been made.

When it is determined to be impractical to store materials within the limits of the project, the CM may approve storage on private property or, for structural units and reinforcing steel, on the manufacturer's or fabricator's yard. Contractor shall provide photographs of materials stored off site. Requests for payment allowance for such stored material shall be accompanied by a release from the owner or tenant of such property or yard agreeing to permit the removal of the materials from the property without cost to VRE. VRE must be allowed access to the materials for inspection during normal business hours.

I. Materials Inventory

If the Contractor requests a payment allowance for properly stored material, they shall submit an itemized inventory statement to the CM along with the monthly Application for Payment. The statement shall be accompanied by supplier's or manufacturer's invoices or other documents that will verify the material's cost. The statement shall also include photos of the material in its stored location, marked with the Contractor's name and the project name.

With each subsequent monthly Application for Payment, the Contractor shall submit to the CM a monthly update of the itemized inventory statement. The updated inventory statement shall show additional materials received and stored with invoices or other documents and shall list materials removed from storage since the last certified inventory statement, with appropriate cost data reflecting the change in the inventory.

1.09 CERTIFIED PAYROLL RECORDS

- A. If this project is identified to be funded in whole or in part by federal grants, the Contractor is required to comply with the Davis Bacon requirements as described in the Contract Documents.
- B. These certified payroll records shall be submitted weekly to the Construction Manager for record. It is the responsibility of the Contractor and Subcontractors to submit electronic (.pdf format) certified payroll records directly to the CM no later than one week following the end of each pay period.
- C. Incorrect or incomplete certified payroll records may delay processing of the monthly Application for Payment.

1.10 APPLICATION FOR PAYMENT AT SUBSTANTIAL COMPLETION

- A. After issuance of the Certificate of Substantial Completion, Contractor may submit an Application for Payment showing 100 percent completion for portion of the Work claimed as substantially complete.
 - 1. Include documentation supporting claim that the Work is substantially complete and statement showing an accounting of changes to the Contract Price.
 - 2. This application shall reflect any Certificates of Partial Substantial Completion that may have been issued previously by VRE.
- B. A list of required Contract substantial completion submittals can be found in Section 01 77 00, "Closeout Procedures."

1.11 FINAL APPLICATION FOR PAYMENT

- A. The Final Application for Payment shall be submitted in the same format as monthly Applications for Payment, as described in Subsection 1.05 above.
- B. Prior to submitting the Final Application for Payment, the Contractor must have provided all required Contract closeout submittals to the CM along with the signed VRE Contract Closeout Checklist. Checklist will be provided to the Contractor by the CM upon request.

- C. A list of required Contract closeout submittals can be found in Section 01 77 00, "Closeout Procedures."
- D. Other items which must be complete prior to final payment and release of retainage shall include, but not be limited to the following:
 - 1. Project Punch List complete and accepted by the CM
 - 2. Demobilization and removal of temporary facilities
 - 3. Final cleaning
 - 4. Commissioning of new systems, as required
 - 5. Training and demonstration of new systems, as required
 - 6. Insurance certificates for products and completed operations where required and proof that taxes, fees and similar obligations were paid.
 - 7. Resolution and execution of final Contract Amendment, if necessary
- E. Contractor must complete all punch list items to the satisfaction of the CM and VRE before Final Completion. Retainage will be withheld until punch list is completed and all submittals have been received and approved. Failure to complete the punch list work within 60 calendar days of issuance, may result in VRE ordering the work to be completed by others at the cost to Contractor and deducting the value of such from retainage withheld.
- F. Release of retainage will be allowed once all Contract closeout submittals are received and accepted by VRE.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 31 00**Project Management and Coordination****PART 1 - GENERAL****1.01 SUMMARY**

Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:

- A. Submittals
- B. Project Management Information System (PMIS)
- C. Authority of VRE Field Representatives
- D. General Coordination Procedures
- E. Requests for Information (RFIs)
- F. Project Meetings

1.02 RELATED SECTIONS

- A. General Conditions for Construction
- B. Section 01 26 00 – Change Order Procedures
- C. Section 01 32 00 – Construction Progress Documentation
- D. Section 01 33 00 – Submittal Procedures
- E. Section 01 35 23 – Safety and Security Requirements
- F. Section 01 45 00 – Quality Assurance and Quality Control
- G. Section 01 73 00 – Execution of Work
- H. Section 01 77 00- Project Closeout

1.03 SUBMITTALS

- A. Coordination Drawings

Before start of the Work, prepare Coordination Drawings, as needed and directed by the CM, for areas with limited space availability that necessitates maximum utilization of space for efficient installation of different components and areas requiring coordination for installation of products and materials fabricated by separate entities.

1. Indicate relationship of components shown on separate Shop Drawings
2. Indicate all dimensions provided on Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted equipment, minimum clearance requirements, amounts of equipment and material to be installed, or other requirements. Provide alternate sketches for resolution of such conflicts to CM for review.

3. Indicate required installation sequences.
4. Comply with requirements contained in Division 01 Section 01 33 00 "Submittals"
5. Prepare coordination drawings of involved trades in a scale of not less than ¼ inch = 1 foot or larger for integration of different construction elements. Show sequence and relationships of separate components to avoid conflicts in use of space. Any Work installed prior to review of coordination drawings will be at the Contractor's risk and subsequent relocation required to avoid interference shall be made at no additional cost to VRE.

B. Subcontract List

The Contractor shall prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Include the following information in tabular form:

1. Name, address, and telephone number of entities performing subcontract or supplying products
2. Description of Work to be performed

All subcontractors are subject to approval by the CM and VRE prior to such subcontractors performing any Work on the project. If subcontractors need to be added to the list as the project progresses, a revised list shall be submitted to the CM for approval, noting changes or additions.

Rejection of a subcontractor by the CM or VRE does not constitute grounds for additional monetary compensation to the Contractor.

C. Key Personnel Names

No later than 14 calendar days prior to the scheduled date of the Preconstruction Conference, the Contractor shall submit a list of key personnel assignments. Key personnel shall include but not necessarily be limited to Project Manager, Project Superintendent, Safety Manager (if applicable) and Quality Control Manager (if applicable). Identify individuals and their duties and responsibilities. For each person, list office address and telephone number, if applicable, mobile telephone number, and e-mail address. Provide names, and telephone numbers of individuals assigned as alternates in the absence of individuals assigned to Project.

Key personnel are subject to approval by VRE.

1.04 PROJECT MANAGEMENT INFORMATION SYSTEM

- A. A Project Management Information System (PMIS) or Project Controls System is a generic term for a proprietary file management collaborative system intended for internet-connected device use. The intent of this application is to enable dispersed users access to shared documents for storage, organization, retrieval, editing, tracking, reporting, or other functions, with such access usually controlled by invitation and security protocols. More than one such application type or specific programs may be used, depending on VRE preferences.

VRE currently employs a well-known PMIS known as eBuilder as their Project Controls system and will not accept any requests for substitution for this program. The Contractor will be required to utilize eBuilder for all project correspondence and coordination, including

submittals, invoices and other functions as directed by VRE. Use of the E-builder Project Management System will not replace or change any contractual responsibilities of the Contractor. The system has been implemented to enhance and expedite team communication.

B. Contractor Responsibilities

1. The Contractor shall provide, at the Contractor's Temporary Site Office, and home office if required, the computer hardware and software to provide access to the E-builder Project Management System.

C. VRE Responsibilities

1. VRE has established the project document management database for this project. VRE will provide management, license(s), training, etc. of the database and interface with the system provider.
2. Any required technical support regarding E-builder shall be directed to the VRE Project Manager.

D. Project Correspondence

1. All Contractor Project correspondence shall be either created electronically or digitized so that it can be issued, administered, stored and tracked by the E-builder Project Management System.
2. The Contractor shall use the VRE provided web-based E-builder Project Management System to transmit, at a minimum, each of the following to the VRE Project Manager:
 - a. Requests for Information (RFI's) and attachments
 - b. Submittals
 - c. Requests for Changes
 - d. Change Orders
 - e. Invoice Approval (Payment Applications)

Responses of the VRE Project Manager's review and action, of the above documents, shall be transmitted to the Contractor through E-builder.

1.05 AUTHORITY OF VRE FIELD REPRESENTATIVES

A. Construction Manager

1. During prosecution of the Work, the CM will answer all questions that may arise as to the quantity, quality, and acceptability of materials furnished and work performed; rate of progress of the Work; interpretation of the plans and Specifications; the Contractor's acceptable fulfillment of the Contract; disputes and mutual rights between contractors; and the Contractor's compensation.
2. The CM has the authority to suspend the Work wholly or in part if the Contractor has created conditions that are unsafe or fails to correct conditions that are unsafe for workers or the general public or fails to carry out the provisions of the Contract. The CM may also suspend the Work for such periods as they may deem necessary because of catastrophic or

extraordinary weather as defined in Section 01 26 00, "Change Order Procedures," conditions considered unsuitable for prosecution of the Work, or any other condition or reason deemed to be in the public interest.

3. The CM may issue written clarifications or field directives that enhance or clarify the intent of the plans and/or specifications. The CM may offer guidance or issue written orders for such work as may be necessary to complete the Contract satisfactorily.
4. If guidance or directives, noted above, by the CM, result in a change to the Contract, VRE will provide written concurrence with the CM for Contract Changes. VRE concurrence must be provided prior to the Contractor performing any Work not in accordance with the Contract Documents.

B. Inspector

1. Inspectors representing VRE and/or the CM are authorized to inspect all work performed and materials furnished. Inspection may extend to all or any part of the Work and to the preparation, fabrication, and manufacture of the materials to be used. The Inspectors are not authorized to alter or waive the provisions of these Specifications or make changes in the plans.
2. The Inspectors are not authorized to make final acceptance of the project, approve any operation or item, or act as foreman for the Contractor. However, the Inspectors will have the authority to reject defective work and material and suspend work that is being improperly performed, subject to the concurrence of the CM. Such inspections shall not relieve the Contractor of any obligation to furnish acceptable materials or provide completed construction that is in accordance with the Contracts requirements.
3. The Inspector will exercise only such additional authority as the CM may delegate.

1.06 GENERAL COORDINATION PROCEDURES

- A. Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations, included in different Sections that depend on each other for proper installation, connection, and operation.
- B. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
- C. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
- D. Make adequate provisions to accommodate items scheduled for later installation.
- E. Administrative Procedures

Coordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's construction schedule
 2. Preparation of the schedule of values
 3. Installation and removal of temporary facilities and controls
 4. Delivery and processing of submittals
 5. Progress meetings
 6. Pre-activity meetings
 7. Project closeout activities
 8. Startup, adjustment and final acceptance of systems
- F. Conservation

Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste. Salvage materials and equipment involved in performance of, but not actually incorporated into, the Work. See other Sections for disposition of salvaged materials that are designated as Owner's property.

1.07 REQUESTS FOR INFORMATION

- A. Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI electronically to the CM, either utilizing a PMIS if directed by VRE, or via email if a PMIS is not being utilized by VRE on the project.
- B. The CM will not accept RFIs submitted by other entities controlled by Contractor (subcontractors, suppliers, etc.). Subcontractor's RFI's shall first be reviewed by the Contractor prior to submission to the CM. All RFIs must be routed through the Contractor to the CM for proper documentation.
- C. The Contractor shall coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of Subcontractors.
- D. The CM will not receive or review RFIs submitted via fax or verbal requests.
- E. Preparation of RFI
 1. Submit one (1) electronic (.pdf) version of the RFI to the CM for review and response.
 2. Include a detailed, legible description of the item needing information or interpretation and the following:
 - a. Contract/Project name
 - b. Contract/Project number
 - c. Date
 - d. Name of Contractor
 - e. RFI number, numbered sequentially

- f. RFI subject
- g. Specification Section number and title and related paragraphs, as appropriate
- h. Drawing number and detail references, as appropriate
- i. Field dimensions and conditions, as appropriate
- j. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
- k. Contractor's signature
- l. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
 - i. Supplementary drawings/sketches prepared by the Contractor shall include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

F. Construction Manager Review and Response

The CM will review each RFI, with the Engineer of Record, determine action required, and respond. Allow seven (7) calendar days for the CM's response to each RFI. RFIs received by the CM after 5:00 p.m. will be considered as received the following business day.

1. The following Contractor-generated RFIs will be returned without action:
 - a. Requests for approval of submittals
 - b. Requests for approval of substitutions
 - c. Requests for approval of Contractor's means and methods
 - d. Requests for coordination information already indicated in the Contract Documents
 - e. Requests for adjustments in the Contract Time or the Contract Sum
 - f. Requests for interpretation of the Engineer's actions on submittals
 - g. Incomplete RFIs or inaccurately prepared RFIs
2. The CM's response may include a request for additional information, in which case the CM's time for response will date from time of receipt of additional information.
3. The CM's response on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for the Contractor to submit a PCO according to Section 012600 "Change Order Procedures."
4. Upon receipt of the CM's response, the Contractor shall review the response and notify the CM within seven (7) calendar days if the Contractor disagrees with the response.
5. VRE's response to an RFI, does not constitute a change in the Contract.

6. If the Contractor thinks the RFI response warrants a change notify the CM, in writing, within 10 days of receipt of the RFI response.
7. Upon receipt of the CM's action, update the RFI log and immediately distribute the RFI response to affected parties.

G. RFI Log

A Project RFI Log will be maintained by the CM and distributed for review at regular Project Progress Meetings. The Contractor shall maintain an identical RFI Log utilized in assigning numbers to new RFIs and managing RFIs in review or in preparation. The following information will be included in the RFI Log:

1. Project name
2. Name of Contractor
3. RFI number including RFIs that were returned without action or withdrawn
4. RFI description
5. Date the RFI was submitted
6. Date Construction Manager's response was received
7. Status of RFI (In Review, Closed, etc.)
8. Identification of related Field Work, Work Change Directive and Proposal Request, as appropriate.

1.08 PROJECT MEETINGS

A. General Information for All Meetings

1. The Construction Manager will schedule and conduct meetings and conferences at Project Field Office unless otherwise indicated.
2. A safety briefing must be conducted prior to beginning all meetings.
3. The CM shall inform participants and others involved, and individuals whose presence is required, of date and time of each meeting.
4. The CM shall prepare the meeting agenda and distribute the agenda to all invited attendees, in advance of the meeting as necessary.
5. The CM shall be responsible for conducting the meeting and will record significant discussions and agreements achieved. The CM shall distribute the meeting minutes to everyone concerned within three business days of the meeting.

B. Preconstruction Conference

1. Within twenty-one (21) calendar days after award of a contract or after notification of award, issued by the Purchasing Department, and prior to the Notice to Proceed date, the Contractor shall attend a preconstruction conference scheduled by VRE to discuss the Contractor's planned operations for prosecuting and completing the Work in accordance

with the Contract. The meeting will review the parties' responsibilities and personnel assignments.

2. Submittals to be provided to the CM no later than seven (7) calendar days prior to the preconstruction conference include, but are not limited to, the following:
 - a. Preliminary Construction Schedule (see Section 01 32 00, "Construction Progress Documentation," for detailed submittal requirements)
 - b. Contractor's Safety Plan (see Section 01 35 23, "Safety and Security Requirements," for detailed submittal requirements)
 - c. Contractor's Quality Management Plan (see Section 01 45 00, "Quality Assurance and Quality Control," for detailed submittal requirements)
 - d. Coordination Drawings (see section 1.03A above)
 - e. Work Plan (see Section 01 32 00, "Construction Progress Documentation," for detailed submittal requirements)
3. The Contractor, the CM, and VRE shall be prepared to discuss key issues and project specific requirements necessary for preparation and submittal of the Baseline Schedule.
4. The CM will be responsible for setting the conference agenda, conducting discussions, and ensuring that minutes of the conference are taken and later distributed to all attendees. The conference agenda may include, but not be limited to:
 - a. Safety and security briefing
 - b. Designation of responsible personnel representing VRE, the CM, Contractor, and others, as appropriate
 - c. Coordination with Host Railroad Operations
 - d. Review of critical work sequencing and draft project schedule prepared by the Contractor
 - e. Designation of key personnel
 - f. Discussion of Construction Schedule, starting, ending and Milestone dates, damages, and bonus & penalty provisions, if any
 - g. Project coordination
 - h. Use of premises
 - i. VRE's requirements regarding ongoing operations
 - ii. Office and storage areas
 - iii. Temporary facilities and controls
 - iv. Temporary utilities
 - v. Contractor's Work area
 - vi. Contractors access and parking

- vii. Work days and Work hours
- viii. Permits
- ix. Right of Entry by Railroad, if any
- i. Procedures for:
 - i. Submittals
 - ii. Substitutions and “or equal” Products
 - iii. Maintaining record documents
 - iv. Applications for payment
 - v. Field Orders, Work Change Directives, Change Orders and Contract Amendments
 - vi. Partial Utilization
 - vii. Emergencies
 - viii. Housekeeping
 - ix. Safety and Security
 - x. Testing and prior notification
 - xi. Identify point of contact
- 5. Attendance: Listed below are invited attendees. Contractor’s required attendees are noted.
 - a. VRE
 - b. Construction Manager
 - c. Contractor Project Manager (required)
 - d. Contractor Superintendent (required)
 - e. Contractor’s Safety Representative (required)
 - f. Major Subcontractors and Suppliers (required)
 - g. Host Railroad representative, as required
 - h. Jurisdictional representative, as required
 - i. Funding partner representatives
 - j. Other major stakeholders, including utilities and impacted adjacent property owners, along with other interested parties as selected by VRE or the CM

C. Project Progress Meetings

- 1. Project Progress Meetings will be scheduled regularly throughout the duration of the project, or as directed otherwise by VRE. At a minimum, progress meetings shall be held monthly. Progress meetings are in addition to specific meetings held for other purposes, such as coordination and special pre-activity meetings. Additionally, discussion will

address administrative and technical issues of concern, determining resolutions, and development of deadlines for resolution within allowable time frames.

2. Attendance required:
 - a. VRE
 - b. Construction Manager
 - c. Contractor Project Manager
 - d. Contractor Superintendent
 - e. Subcontractors as pertinent to agenda
 - f. Suppliers and/or manufacturers' representative as pertinent to agenda
3. Agenda:
 - a. Safety briefing
 - b. Review and approval of minutes of previous meetings
 - c. Review safety and security
 - d. Review work progress and planned work
 - e. Discuss field observations, potential conflicts and decisions
 - f. Identification of problems which impede planned progress
 - g. Review of submittals schedule and status of submittals
 - h. Review of off-site fabrication and delivery schedules
 - i. Two Week Look-Ahead Schedule
 - j. Coordination of projected progress
 - k. Status of proposed changes and any effect on progress schedule and coordination
 - l. Other business relating to work
4. Minutes will be prepared by the CM and distributed to attendees. Should any attendee disagree with the contents of the minutes as prepared, they shall identify the information they feel is inaccurate and forward it, with corrections, to the author of the minutes, within seven (7) calendar days of receipt of the minutes.
5. The Project Progress Meetings will be held at the Project Field Office, unless otherwise directed by the CM or VRE.
6. Contractor's Construction Schedule: Review progress since last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's Construction Schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

7. Two-Week Look Ahead Schedule: Contractor shall submit at the progress meeting, or as requested by the CM, a two-week look-ahead schedule. This schedule shall include a three-week period, one week showing actual progress from the previous week and two weeks showing planned work for the two weeks after the meeting date. Include in the schedule all activities in sufficient detail as approved by the CM. A two-week look ahead schedule format will be discussed at the pre-construction schedule.
8. Schedule Update: Revise Contractor's Construction Schedule after each progress meetings where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

D. Pre-Activity Meetings

1. When required by individual specifications sections, or requested by the CM, the Contractor shall hold a pre-activity meeting at the site or field office prior to commencing work of the section. Work may or may not require coordination with other construction. Arrange sufficiently in advance to allow attendance by indicated parties.
2. Attendance:
 - a. VRE
 - b. Construction Manager
 - c. Contractors and subcontractors directly affecting or affected by the work of the section
 - d. Material suppliers and/or manufacturer's representatives as required by the individual section
3. Agenda: Review progress of other construction activities and preparations for the particular activity under considerations, including requirements for the following:
 - a. Contract Documents
 - b. Possible conflicts
 - c. Safety briefing
 - d. Review conditions of installation
 - e. Review preparation and installation procedures
 - f. Review coordination with related work
 - g. Where Coordination Drawings are required (See Section 1.03 above)
 - h. Time Schedules
4. Do not proceed with installation if the meeting cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the meeting at the earliest feasible date.

E. Project Closeout Meeting:

1. Schedule and conduct a Project closeout conference, at a time convenient to Owner and Architect, but no later than 30 days prior to the scheduled date of Final Completion.

Conduct the meeting to review requirements and responsibilities related to Project closeout.

2. Attendance:
 - a. VRE
 - b. Construction Manager
 - c. Designer of Record
 - d. Contractor Project Manager
 - e. Contractor Superintendent
 - f. Contractors, subcontractors and suppliers directly affecting or affected by the work of the section
 - g. Participants at the meeting shall be familiar with the Project and authorized to conclude matter relating to the Work.
3. Agenda: Discuss items of significance that could affect or delay Project closeout, including but not limited to the following:
 - a. Closeout Checklist
 - b. Preparation of record documents
 - c. Procedures required prior to inspection for Substantial Completion and for final inspection for acceptance
 - d. Submittal of written warranties
 - e. Requirements for preparing sustainable design documentation
 - f. Requirements for preparation operations and maintenance data
 - g. Requirement for demonstration and training
 - h. Preparation of Contractor's punch list
 - i. Procedures for processing Application for Payment at Final Completion and final payment
 - j. Submittal procedures
 - k. Owner's partial occupancy requirements
 - l. Responsibility for removing temporary facilities and controls.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 32 00**Construction Progress Documentation****PART 1 - GENERAL****1.01 SUMMARY**

Section includes administrative and procedural requirements for documenting the progress of construction during performance of the Work, including but not limited to, the following:

- A. Construction Schedule
- B. Workplan (Narrative)
- C. Contractor Daily Reports
- D. Contractor Monthly Reports

All costs incurred by Contractor to correctly implement and update the schedule shall be borne by the Contractor and are part of this Contract.

1.02 RELATED SECTIONS

- A. Section 01 26 00 – Change Order Procedures
- B. Section 01 29 00 – Payment Procedures
- C. Section 01 33 00 – Submittal Procedures
- D. Section 01 35 23 – Safety and Security Requirements
- E. Section 01 77 00 – Closeout Procedures

1.03 DEFINITIONS

Activity: A discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction project. Activities included in a construction schedule consume time and resources. Each activity is assigned a unique description, activity number and activity code .

Critical Activity: An activity on the critical path that must start and finish on the planned early start and finish times.

Predecessor Activity: An activity that precedes another activity in the network.

Successor Activity: An activity that follows another activity in the network.

Calendar Day: Any day shown on the calendar, including Saturday and Sunday, beginning at 12:01 a.m. and ending at midnight.

CPM: Critical path method, which is a method of planning and scheduling a construction project where activities are arranged based on activity relationships. Network calculations determine when activities can be performed and the critical path of Project.

Critical Path: The longest connected chain of interdependent activities through the network schedule that establishes the minimum overall Project/Contract duration and contains no float.

Critical Path Work: Any work on the critical path. A delay to any critical path work is expected to delay completion of the project.

Day: A Calendar Day, unless specifically stated otherwise.

Event: The starting or ending point of an activity.

Final Completion: For the purpose of the Construction Schedule only, Final Completion shall be the date in which all Work at the site is complete, including punch list activities, final inspections, final cleaning, and demobilization.

Float: The measure of leeway in starting and completing an activity.

Free Float: The amount of time an activity can be delayed without adversely affecting the early start of the successor activity.

Total Float: The measure of leeway in starting or completing an activity without adversely affecting the planned Project completion date.

Milestone: An event or a date that marks the start or completion of a specified portion of the Work. If provided for in the Contract, milestones are used to specify when the Work or a specified portion thereof must be completed in accordance with the Contract Documents. The Contract may provide for one or more Completion milestones.

Preliminary Schedule: A CPM schedule covering all Contractor activities to be started and/or completed within the first 30 calendar days of the Project/Contract duration.

Project/Contract Duration: The total time, in calendar days identified in the Contract Documents, representing the duration necessary for completion of all physical and administrative requirements under this Contract and any authorized extension thereof.

Record As-Built CPM Contract Schedule: A Record Contract Schedule accurately reflecting actual progress of Work and is submitted as part of this Contract's Record Documents. All activities shall have actual dates that are true and accurate.

1.04 PRELIMINARY CONSTRUCTION SCHEDULE

- A. The Contractor shall submit a Preliminary Construction Schedule to the CM for information no later than seven (7) calendar days prior to the scheduled date of the Preconstruction Conference. Within 7 calendar days, the CM will respond with approval or direction to change and the Contractor shall resubmit within 7 calendar days, if required.
- B. The preliminary schedule shall be utilized by the CM and VRE to coordinate initial work until a Baseline CPM Construction Schedule is submitted and approved. The preliminary schedule shall include all activities planned for the first 30 calendar days following Notice to Proceed and the format shall be horizontal bar-chart style (Gantt) and demonstrate the anticipated critical path.
- C. One electronic file copy of the working schedule which can be opened in the construction scheduling software used to prepare the schedule. For example, a ".xer" file for Primavera P6 and ".mpp" file for Microsoft Project. VRE employs Microsoft Project and generally prefers

- delivery in this format. The Contractor shall be prepared to discuss his planned operations relative to the Contract requirements at the Pre-Construction Conference.
- D. The preliminary schedule shall include, but not be limited to, the following:
1. Mobilization
 2. Permitting
 3. Major construction activities
 4. Milestone events as required by the Contract Documents
- E. The Preliminary Construction Schedule is not required if the Baseline Construction Schedule is submitted for approval no later than seven (7) calendar days prior to the scheduled date of the Preconstruction Conference. It shall include the Contractor's work plan (narrative) for mobilization, procurement and completion within the Contract Duration. The work plan shall elaborate on the basis for durations, production rates, major equipment to be used and shall identify all major assumptions used to develop the preliminary schedule.

1.05 WORK PLAN (NARRATIVE)

- A. The Contractor shall prepare a work plan, as indicated in this document, to complete the Work within the Contract Duration and complete those portions of works related to each intermediate milestone date, if applicable, and other Contract requirements.
- B. The Work Plan shall, at a minimum, include: an explanation of the basis for the Contractor's determination of construction logic, estimated durations, hours per shift, workdays per week and types, numbers, capacities and placement of major construction equipment to be used, construction access, MOT for vehicles, pedestrians and trains, staging and laydown areas, parking for construction personnel, temporary field office location and security of these items. A listing of nonworking days and holidays incorporated into the schedule shall be provided.
- C. The Work Plan shall be reviewed and approved by the CM and Project Stakeholders, which may include Host Railroad, Utility Owners, Local Jurisdiction or Adjacent Property Owners.
- D. Specific work activities (such as crane and steel erection or heavy equipment/load placement) may require specific submittals and approval along with applicable pre-activity coordination.

1.06 CPM CONSTRUCTION SCHEDULE, BASELINE

- A. The Contractor shall submit the Baseline Construction Schedule to the CM for review and acceptance within seven (7) calendar days following Notice to Proceed. The Baseline Construction Schedule submittal shall be a computerized time-scaled CPM schedule in PDF format that includes the following:
1. A transmittal letter to the CM listing the items, date, and number of copies of items being submitted.
 2. One printed legible color copy of the schedule according to Early Start of all activities. The schedule shall be printed on 11"x17" paper or larger as required to display the entire schedule for the entire construction period in a legible manner.

3. One electronic (.pdf) copy of a narrative (work plan) that presents the construction approaches and explains the schedule logic.
 4. One electronic (.pdf) copy of the schedule.
 5. One electronic file copy of the working schedule which can be opened in the construction scheduling software used to prepare the schedule. For example, a “.xer” file for Primavera P6 and “.mpp” file for Microsoft Project. VRE employs Microsoft Project and generally prefers delivery in this format.
- B. Each electronic file submittal shall have a unique file name indicating the Project name, submission type and number, and data date of the submission (e.g. ProjectName_Baseline01_2016.12.01.pdf).
- C. The Baseline Construction Schedule shall represent the Contractor’s overall work plan to accomplish the entire scope of work in accordance with the requirements of the Contract. The Baseline Schedule shall include all work including, as applicable, the work to be performed by sub-contractors, VRE, or others.
- D. The Baseline Schedule shall employ CPM using retained logic for the planning, scheduling, and reporting of the work to be performed under the Contract. The Critical Path shall be shown clearly on the schedule.
- E. Each construction activity shall be part of a logic diagram. The logic diagram shall show a documentable critical path. Each activity should have a predecessor and a successor with the exception of NTP and Final Completion.
- F. The construction schedule shall show a detailed order of construction activities based on predecessor and successor activities and shall be developed using Primavera P6 or Microsoft Project.
- G. When preparing the Baseline Schedule, the Contractor shall consider all known constraints and restrictions such as holidays, seasonal, weather, traffic, utility, railroad, right-of-way, environmental, permits, or other known or specified limitations to the work. Schedule shall include work performed by VRE or utility agencies and other third parties that may affect or be affected by Contractor’s activities.
- H. Extend schedule from date established for the Notice to Proceed to date of Final Completion.
- I. Contract completion date(s) shall not be changed by submission of a schedule that shows late completion date, unless specifically authorized by a Contract Amendment.
- J. Treat each Work element as a separate numbered activity. Grouping of activities is acceptable provided the items are closely related and will be constructed in conjunction with one another. Include the following as separate activities and milestones as shown:
1. Notice to Proceed (milestone)
 2. Mobilization
 3. Review Period for General Submittals
 4. Review Period for Major Material Submittals

5. Fabrication and Delivery of Major Materials
 6. Construction and Installation of Specific Work Items
 7. Work by Others that may affect Contractor Work
 8. Startup and Testing
 9. Commissioning
 10. Demonstration and Training
 11. Completion of Work Phases, as defined in the Contract
 12. Substantial Completion (milestone)
 13. Punch List
 14. Final Completion (milestone)
- K. Include a separate activity for each portion of the Work performed by VRE or Others. Dates and durations are to be inserted as directed by the CM or VRE.
- L. Each construction activity shall contain a start date, a finish date, and duration not in excess of fourteen (14) calendar days.
- M. The Baseline Schedule submittal shall include a written Workplan/Narrative to describe the Contractor's proposed general sequence to accomplish the work in terms of the major operations, routes, or segments of work as delineated in the Contract or in the absence of such delineations, as agreed to by the Contractor and VRE.
- N. Critical Path Activities
- The Contract CPM Schedule shall be prepared to include the data for the total Contract and the critical path activities shall be identified, including critical paths for interim completion dates. Scheduled start or completion dates imposed on the schedule by Contractor shall be consistent with Contract milestone dates. Milestone dates shall be the scheduled dates specified in the Contract Documents, if applicable, and shall be prominently identified. The Contract CPM Schedule shall accurately show all as-built activities completed from the issuance of the Notice to Proceed up to the submittal of this schedule.

1.07 CPM CONSTRUCTION SCHEDULE, MONTHLY UPDATE

- A. Following acceptance of the Baseline Construction Schedule by the CM, the Contractor shall submit the Monthly Update Construction Schedule every month to the CM for review and approval along with the Contractor's monthly Application for Payment. Approval of Contractor's monthly Application for Payment shall be contingent, among other factors, on the submittal of a satisfactory monthly schedule update. The Monthly Update Construction Schedule submittal shall include the following:
1. One printed legible color copy of the schedule according to Early Start of all activities. The schedule shall be printed on 11"x17" paper or larger as required to display the entire schedule for the entire construction period in a legible manner.
 2. One electronic (.pdf) copy of a Narrative (Work Plan)

3. One electronic (.pdf) copy of the schedule
 4. One electronic file copy of the working schedule which can be opened in the construction scheduling software used to prepare the schedule
- B. Each electronic file submittal shall have a unique file name indicating the Project name, submission type and number, and data date of the submission (e.g. ProjectName_Update01_2016.12.01.pdf).
- C. The Monthly Update Schedules shall be prepared in the same manner as the Baseline Schedule and shall reflect actual construction progress and activities. Monthly schedule updates shall be the product of joint review meetings, of a draft updated schedule, between the Contractor, CM and applicable active subcontractors. The joint review shall focus on actual progress for the preceding month, planned progress for the upcoming month supported a Contractor-prepared Two-Week Look-Ahead Schedule, impact to schedule if any due to change notices issued, adverse weather and any affect changes to the Construction CPM Schedule. The agreed-on progress, and changes, if any, shall be incorporated into the schedule update to be submitted. The update shall always represent the actual history of accomplishment of all activities and will form the basis for Contractor's Application for Payment.
- D. All requirements for the Baseline Schedule described above in this Specification section also apply to the Monthly Update Schedules.
- E. The Data Date for each Monthly Update Schedule shall be the first calendar day of every month.
- F. As the Work progresses, indicate completion percentage for each activity.
- G. The Monthly Update Schedule submittal shall include a written Narrative to:
1. List and describe schedule activities progressed during the previous calendar month
 2. List and describe schedule activities planned to be progressed during the upcoming calendar month
 3. Describe all changes to logic, durations, actual starts and finishes, and added or deleted activities
- H. Changes to schedule logic are subject to approval by the CM.
- I. Failure by the Contractor to include any element of work required for performance of the Contract shall not relieve the Contractor from completing all work within the Contract time. Such omission or error, when detected by the Contractor or the CM, shall be corrected prior to the next issue of the Monthly Update, without increasing the project's performance time.
- J. If critical activities of the schedule are delayed and such delay is not excusable as defined in this Section, the remaining sequence of activities and/or duration thereof shall be adjusted by Contractor through measures such as additional manpower, additional shifts or the implementation of concurrent operations until the schedule produced indicates Work will be completed on schedule. Except as provided elsewhere in the Contract, all costs incurred by Contractor to recover from inexcusable delays shall be borne by the Contractor.

- K. The monthly schedule update shall support the Contractor's Application for Payment. The progress payment for an activity shall be based on its agreed percentage of completion. On unit-priced contracts, the approval of Contractor's monthly requisition is contingent on the submittal of a satisfactory monthly schedule update; however, the basis of payment will be the actual measurement of CM-accepted, in-place units of work.

1.08 TWO WEEK LOOK-AHEAD SCHEDULE

- A. The Contractor shall submit a Two Week Look-Ahead Schedule in electronic (.pdf) format to the CM for information on a weekly basis. The submittal day shall be at the progress meeting, unless otherwise directed by the CM. The Two Week Look Ahead schedule may be a horizontal bar-chart style schedule, in lieu of a CPM schedule, if desired. The Contractor shall be prepared to discuss his planned operations for the upcoming two weeks at each Project Progress Meeting.
- B. The Two Week Look-Ahead Schedule shall provide a detailed list of operations to indicate the type of operation, locations of the work, proposed working days and hours, and the start and finish dates for any work planned, started, in progress, or scheduled for completion during the two-week period. The Two Week Look-Ahead Schedule shall also indicate any critical stages of work requiring VRE oversight or inspection.
- C. The Contractor may revise his Two Week Look-Ahead Schedule at his discretion. However, the Contractor shall notify the CM at least 24 working hours in advance of any changes in the Contractor's planned operations or critical stage work requiring VRE oversight or inspection. In the event of extenuating circumstances deemed by VRE to be beyond the Contractor's control, VRE may grant verbal concurrence of changes in the Contractor's planned operations with less advance notice, as the need arises.

1.09 CPM CONSTRUCTION SCHEDULE, REVISIONS

- A. The Contractor may revise his overall plan of operations at any time; however, the Contractor shall submit a Revised Baseline Schedule to reflect any changes in his overall sequence of operations or general schedule if directed by the CM.
- B. When required by the CM, the Revised Baseline Schedule shall be submitted within seven (7) calendar days of receipt of the CM's written request. The Revised Baseline Schedule shall be submitted in the form of the initial Baseline Schedule as defined in this Specification section, to reflect the changes in the Contractor's overall work plan. The accepted Revised Baseline Schedule will replace any previously accepted Baseline Schedule for the remainder of the work.

1.10 RECOVERY SCHEDULE

If, in the opinion of the CM, the Contractor falls twenty-one (21) or more calendar days behind the approved Baseline Schedule, the Contractor shall take any and all steps necessary to improve progress. The CM may require the Contractor to submit a Recovery Schedule, for review and acceptance by the CM, detailing the specific operational changes to be instituted to regain the accepted Baseline Schedule, all without additional cost to VRE. Indicate changes to working hours, working days, crew sizes, and equipment required to achieve compliance, and date by which recovery will be accomplished.

1.11 DELAYS AND REQUEST FOR TIME EXTENSION

- A. The determination for an extension of the Contract Time will be made by VRE. VRE will not allow time extensions for the normal and seasonal weather conditions considered typical for a given month in accordance with the National Oceanic and Atmospheric Administration (NOAA) thirty year mean for Washington National Airport.
- B. Contractor acknowledges and agrees that delays in activities, irrespective of the party causing the delay, which does not affect any critical activity or milestone dates on the Critical Path, at the time of the delay, shall not become the basis for an extension of the Contract Time. The only basis for any extension of time will be the demonstrated impact of an excusable delay on the critical path. In demonstrating such impact, Contractor shall provide adequate detail as required by the Contract, and Contractor shall prove that:
 - 1. An event occurred.
 - 2. Contractor was not responsible for the event in that the event was beyond the control of Contractor, and was without fault or negligence of Contractor, subcontractor, or supplier, and the event was unforeseeable.
 - 3. Activities on the Critical Path of the Work were delayed.
 - 4. The event in fact caused the delay of the Work.
 - 5. The requested additional time is an appropriate and reasonable extension of the Contract Time, given the actual delay encountered.
- C. Time Extensions for Unusually Severe Weather:
 - 1. If unusually severe weather conditions are the basis for a request for an extension of the Contract Time, such request shall be documented by data substantiating that weather conditions were abnormal for the period of time and could not have been reasonably anticipated, and that weather conditions had an adverse effect on the Critical Path activities of the scheduled construction. The Contractor may request extension to the Time for Completion if it can demonstrate unusual and disruptive weather conditions per the requirements below:
 - a. That one or more of the adverse weather conditions listed below was encountered.
 - b. The occurrence of the adverse weather condition(s) resulted in an inability to prosecute critical work which would have otherwise been performed on the day(s) the Weather Condition(s) occurred.
 - c. The work which was not able to be completed was on the Critical Path and could not be completed **only** due to the adverse weather condition(s) claimed.
 - 1. It shall be the Contractor's responsibility to provide the necessary documentation to satisfy the CM that the weather conditions claimed were encountered, which may include daily reports by the Contractor, copies of notification of weather days to the CM, NOAA backup, and pictures from each day claimed.

2. The Contractor must provide notice of delay to the CM no later than five (5) calendar days after the onset of the delay which satisfies the criteria listed above. A fully documented claim for a time extension under this section shall be submitted no later than thirty (30) calendar days after the cessation of the delay. It shall be the Contractor's responsibility solely to provide the necessary documentation to satisfy the CM that the Weather Condition(s) claimed were encountered.
3. The schedule of anticipated monthly adverse weather condition(s) below will constitute the base line for monthly (or a prorated portion thereof) weather/time evaluation by the Contracting Officer. On issuance of the Notice to Proceed and continuing throughout the Contract on a monthly basis, actual adverse weather days will be recorded by Contractor on a calendar day basis (include weekends and holidays) and compared to the monthly anticipated adverse weather days set forth below.
 - a. For purposes of this clause, the term "actual adverse weather days" shall include days that can be demonstrated to have been impacted by adverse weather.
 - b. The adverse weather conditions listed below will be the only basis for consideration by VRE, based upon the requirements listed above, as an extension of the Time for Completion due to inclement weather or weather-related site conditions.
 - c. Unusually Heavy Precipitation

The Monthly Anticipated Adverse Weather Calendar Days listed below illustrates anticipated monthly inclement weather due to precipitation (Rain and Snow Days). If the number of days with precipitation in excess of 0.10", as recorded at Washington Reagan National Airport, exceeds the Monthly Anticipated Adverse Weather Calendar Days, the Contractor will be entitled to an extension of one (1) day on the Time for Completion for every day in excess of the Monthly Anticipated Adverse Weather Calendar Days illustrated below. The anticipated value of Rain/Snow Days for partial months at the beginning and end of the Contract shall be evaluated on a pro-rated basis.

Weather days are not exclusive to the individual months that they represent in Monthly Anticipated Adverse Weather Calendar Days illustrated below. If weather days are not used in a previous month(s) they can be used to offset weather delays in subsequent months. This will be reviewed on a case by case basis and is subject to reconciliation.

- d. Temperature

The Contractor may be entitled to an additional day for every day that the recorded high temperature at Washington Reagan National Airport is 32 degrees Fahrenheit or less, that has not already been incurred under Monthly Anticipated Adverse Weather Calendar Days listed below. This condition does not apply to vertical construction.

- e. Monthly Anticipated Adverse Weather Calendar Days:
- January – 7, February – 5, March – 6, April – 6, May – 8, June – 6, July – 6,
August – 7, September – 5, October – 5, November – 5, December - 6.
- f. The number of actual adverse weather days shall be calculated chronologically from the first to the last day in each month. Contractor shall not be entitled to any claim for time extension based on adverse weather unless the number of actual adverse weather days exceeds the number of anticipated adverse weather days. In preparing the Contract Schedule, Contractor shall reflect the above anticipated adverse weather days on all weather-dependent activities. Weather-caused delays shall not result in any additional compensation to Contractor.
1. On days where adverse weather is encountered, Contractor shall list all critical activities under progress and shall indicate the impact adverse weather had, if any, on the progress of such activities. This information shall be presented at the end of the adverse weather day to the CM or its authorized representative for its review and approval.
 2. The CM will determine the Contractor's entitlement to an extension of the Time for Completion. A time extension of no more than one (1) day will be granted for one (1) day of lost work which satisfies the requirements above, regardless of the number of adverse Weather Conditions encountered. The Contractor's sole relief shall be an extension of the Time for Completion and no claim for an increase in Contract Amount will be allowed.
 3. If Contractor is found eligible for an extension of the Contract Time, the Contracting Officer will issue a modification extending the time for Contract completion. The extension of time will be made on a calendar day basis.

1.12 IMPACT ANALYSIS SCHEDULE FOR TIME EXTENSION REQUESTS

- A. The Contractor shall submit an Impact Analysis Schedule for all time extension requests in order to determine the impact on the project schedule of a change in the Work or condition, or of a delay event, for the purposes of quantifying and apportioning the effects to the party responsible for the impact.
- B. Time-impact analysis shall illustrate impact during update period in which event occurred, that event has been mitigated to greatest possible extent, and that event still impacts overall completion of Project. No extension to the Time for Completion shall be granted unless the additional or change to the Work increases the length of the critical path beyond the Time for Completion as demonstrated on the approved CPM schedule or bar chart schedule.
- C. Include with request, two copies of submittal of impacted schedule, in electronic format, and photocopies of all relevant documents that support the claim.
- D. Submit all required items within the following time periods:
1. 14 calendar days of event occurrence.
 2. 14 calendar days of Contractor's knowledge of impact.

3. 14 calendar days of written request by CM.
- E. Expiration of time periods without submittal shall constitute forfeiture of rights for these specific impacts.

1.13 FINAL AS-BUILT CPM CONSTRUCTION SCHEDULE

- A. Upon completion of the Project, the Contractor shall submit a Final As-Built CPM Construction Schedule. The As-Built CPM Construction Schedule shall include the following:
 1. One printed legible color copy of the schedule showing actual start and finish dates for all work activities and milestones, based on the accepted monthly updates. . The schedule shall be printed on 11"x17" paper or larger as required to display the entire schedule for the entire construction period in a legible manner.
 2. One electronic (.pdf) copy of the schedule
 3. One electronic file copy of the working schedule which can be opened in the construction scheduling software used to prepare the schedule
- B. The As-Built Schedule shall be prepared in the same manner as the Baseline Schedule and Monthly Update Schedules and shall reflect actual start and finish dates of all activities through Substantial Completion, Punchlist, and Final Completion. All requirements for the Baseline Schedule and Monthly Update Schedules described above in this Specification section also apply to the As-Built Schedules.

1.14 SCHEDULE REVIEW AND ACCEPTANCE

- A. The CM will review the Baseline Schedule, Monthly Updates, and any Revised or Recovery Schedules submitted and provide a written response to the Contractor noting acceptance or rejection and applicable comments. Review and acceptance by the CM will be based on conformance with the requirements of this provision and the Contract.
- B. The accepted Baseline Schedule and subsequent Monthly Updates will be used by the CM and VRE for planning and coordination of VRE activities, resources, and expenditures, and for evaluation of the Contractor's rate of progress and the effects of time-related impacts on the project.
- C. Review and acceptance by the CM will not constitute a waiver of any Contract requirements and will in no way assign responsibilities of the work plan, scheduling assumptions, and validity of the work plan or schedule to VRE. Failure of the Contractor to include any element of work required by the Contract for timely completion of the Contract in the Construction Schedule shall not excuse the Contractor from his contractual obligations.
- D. If requested by the CM, the Contractor shall meet with the CM to present and discuss the Monthly Update Schedule.

1.15 FAILURE TO COMPLY WITH SCHEDULE SUBMISSION REQUIREMENTS

- A. If the Contractor fails to comply with any of the Construction Schedule submission requirements within the time and in the manner specified, VRE may withhold approval of the Contractor's ensuing monthly application for payment until the Contractor has satisfied the

- submission requirements. If the Contractor fails to submit the Final As-Built Schedule in the time and manner required, VRE may withhold approval of the final payment until the Contractor satisfies the submission requirement.
- B. VRE shall not be responsible for any delays, costs, or damages resulting from the Contractor's failure to submit the schedule submittals in accordance with the requirements of the Contract.
 - C. Failure to include any work item required for performance of this Contract shall not excuse the Contractor from completing all work within applicable completion dates, regardless of CM approval of the Schedule.

1.16 DAILY CONSTRUCTION REPORTS

- A. The Contractor shall submit written Daily Reports in electronic (.pdf) format to the CM for information on a weekly basis. Submit copies to the CM by noon on the day following the date of actual progress, or as otherwise determined by the CM.
- B. The Contractor Daily Report format shall be acceptable to the CM. A standard VRE format will be provided to the Contractor by the CM, if required.
- C. Daily Reports shall include, at minimum, the following information concerning events at Project site:
 - 1. Approximate count of Contractor personnel at Project site (e.g. 1 Superintendent, 2 Foremen, 3 Carpenters, etc.)
 - 2. List of Subcontractors at Project site
 - 3. Approximate count of Subcontractor personnel
 - 4. Beginning and ending time of Work
 - 5. Equipment at Project site, noting whether in use or idle (include make and model of equipment as well as general description (e.g. John Deere 330 LC Excavator)
 - 6. High and low temperatures and general weather conditions, including presence of precipitation
 - 7. Locations of Work
 - 8. Description of Work performed
 - 9. Specific Tests or Inspections completed, including results (pass/fail)
 - 10. Material deliveries
 - 11. Meetings and significant decisions
 - 12. Directives provided by VRE if differing from the Contract
 - 13. Stoppages, delays, shortages, and losses
 - 14. Accidents
 - 15. Visitors to site (including VRE)
 - 16. Safety compliance or issues

17. Other problems on site

1.17 MONTHLY CONSTRUCTION REPORTS

- A. The Contractor shall submit written Monthly Reports in electronic (.pdf) format to the CM for information along with each monthly Application for Payment.
- B. The Contractor Monthly Report format shall be acceptable to the CM. A standard VRE format will be provided to the Contractor by the CM, if required.
- C. Monthly Reports shall include, at minimum, the following information:
 - 1. All basic project information
 - 2. A brief written summary of major construction performed or completed in the period.
 - 3. Construction photos showing before and after conditions during the period.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 32 33**Photographic Documentation****PART 1 - GENERAL****1.01 SUMMARY**

Section includes administrative and procedural requirements for the following:

- A. Preconstruction Photographs
- B. Monthly Construction Progress Photographs Contractor
- C. Substantial/Final Completion Construction Photographs
- D. Significant Activity Time Lapse Sequence Photographs or Video Records
- E. Additional Photographs

1.02 RELATED SECTIONS

- A. General Provisions, General Conditions and Special Provisions
- B. Section 01 22 00 – Unit Prices
- C. Section 01 29 00 – Payment Procedures
- D. Section 01 33 00 – Submittal Procedures
- E. Section 01 77 00 – Closeout Procedures

1.03 SUBMITTALS

Submit a plan of the Project site including a detailed description of each project area with notation of vantage points marked for location and direction of each photograph. Include same label information as the corresponding set of photographs.

1.04 PHOTOGRAPHS, GENERAL

- A. Photographic Media
 - 1. Digital photos shall be taken on a Manual Single Lens digital camera with a minimum resolution of 8 megapixels. Use lenses with focal length of either 50 mm or 55 mm.
 - 2. Format: Minimum 3200 by 2400 pixels, in unaltered original files, with same aspect ratio as the sensor, uncropped, in a folder named by date of photograph.
 - 3. Date and Time Stamp: Unless otherwise indicated, date and time stamp each photograph as it is being taken so stamp is integral to photograph.
 - 4. Photos shall be submitted to the CM in electronic (.jpg) or other approved format. Each photo shall be captioned or labeled so that the following data is recorded for each photo:
 - 1. Contract number
 - 2. Project name
 - 3. Date and time of day photo taken

4. Photo number
5. Specific location of photo and direction facing (North, West, etc.)
6. Description of work in progress or problem encountered

B. Photographs General

1. Submit digital images exactly as originally recorded in the digital camera without alteration, manipulation, editing or modifications using image-editing software.
2. Take photographs using the maximum range of depth of field, and that are in focus, clear, well-lighted without obscuring shadows, to clearly show the Work. Photographs with blurry or out-of-focus areas will not be accepted.
3. Field Office Digital Photos: Retain one set of digital photos of progress photographs in the field office at Project site, available at all times for reference. Identify photographs the same as for those submitted to CM.
4. Vantage points, times and conditions for camera stations and photography shall be mutually agreed upon by the CM and Contractor.

1.05 CONSTRUCTION PHOTOGRAPHS

A. Preconstruction Photographs:

1. Prior to Mobilization, the Contractor shall take preconstruction photographs of the Project site and surrounding properties, including existing items to remain during construction, from different vantage points, to provide a visual record of the state of Project site prior to disturbance by the Contractor.
2. Pay special attention to existing structures, buildings, platforms, utilities, and adjacent roadways or railways either on or adjoining the project to accurately record the physical conditions at start of construction.
3. The number of preconstruction photos and locations shall be sufficient enough to show all areas within the Limits of Disturbance and adjacent properties, as necessary. The photos shall be coordinated with the CM to ensure proper coverage or areas.
4. Preconstruction photos shall be prepared and submitted as described below for monthly Construction Photographs.
5. Submit photos within one day of taking photographs.

B. Monthly Construction Progress Photographs:

1. Following Mobilization, the Contractor shall submit to the CM, for information, a series of digital photographs taken each month of progress and/or problems which affect his performance. These photos shall be submitted monthly with the Contractor's Application for Payment.
2. The number of photos and locations shall be based on the amount of progress and/or problems encountered each month but should be sufficient enough to show all areas of Work. The photos shall be coordinated with the CM to ensure proper coverage or areas to

best show status of construction and progress since the last photographs were taken. For informational purposes, each new stage of work shall be photographed to include major work areas and activities in progress.

a. Vantage points may be change as the Work progresses, at no additional cost to VRE.

3. Monthly Construction Photographs shall be taken within seven (7) calendar days before the last day of the calendar month. Submit photos within 1 day of taking photographs.

C. Substantial/Final Completion Construction Photographs:

1. Following Demobilization, the Contractor shall take ten (10) post-construction photographs of the Project site and surrounding properties from different vantage points to provide a visual record of the state of Project when all physical work is complete and the Contractor demobilizes from the site. CM will direct photographer for desired vantage point.
2. Do not include date stamp.
3. Submit photos within one (1) day of taking photographs.

D. Significant Activity Time Lapse Sequence Photographs or Video Records

1. At VRE's discretion, any activities that require pre-activity submittals and conference, VRE may request Time Lapse Photographs and/or Video Records of the entire activity.

a. Time Lapse Sequence Photographs

- i. Take photographs to show status of construction and progress. The number of photos and locations shall be sufficient enough to show all areas of Work.
- ii. The photos shall be coordinated with the CM to select best vantage points. Contractor shall take not less than two of the required shots from the same vantage point each time to create a time-lapse sequence of the activity.

b. Video Records

- i. Submit video recording in digital format acceptable to the CM.
- ii. Recording: Mount camera on tripod before starting recording unless otherwise necessary to show area of construction. Display continuous running time and date. At start of each video recording, record weather conditions and the actual temperature reading at Project site.
- iii. Narration: Describe scenes on video recording to include description of items being reviewed, recent events and planned activities. At each change in location, describe vantage point, location and direction (by compass point).
 1. Confirm date and time at beginning and end of recording.
 2. Begin each video recording with name of the Project, Contractor's name and Project location.

- iv. Transcript: Provide a type written transcript of the narration. Display images and running time captured from video recording opposite the corresponding narration segment.
- v. Time Lapse Sequence Video Recording: Record video recording to show status of construction and progress.
 - 1. Frequency: During each of the construction activities, set up video recorded to automatically record one frame of video recording every five (5) minutes, from same vantage point each time, to create a time-laps sequence of thirty (30) minutes in length.
 - 2. Vantage Points: The photos shall be coordinated with the CM to select best vantage points.

- 2. Payment for Time Lapse Photographs and/or Video Records shall be paid for by Contract Modification and are note included in the Contract Price.

E. Additional Photographs:

- 1. CM may issue requests for additional photographs, in addition to periodic photographs specified. Additional photographs will be paid for by Contract Modification and are not included in the Contract Price.
 - 1. Photographer will be given three (3) days' notice, where feasible.
 - 2. In emergency situations, photographer shall take additional photographs within twenty-four (24) hours of request.
 - 3. Circumstances that could require additional photographs include, but are not limited to, the following:
 - a. Special events planned at Project site.
 - b. Immediate follow-up when on-site events result in construction damage or losses.
 - c. Photographs to be taken at fabrication locations away from Project site.
 - d. Substantial Completion of a major phase or component of the Work.
 - e. Extra record photographs at time of final acceptance.
 - f. CM's request for special publicity photographs.

F. Usage Rights:

- 1. Obtain and transfer copyright usage rights from photographer and videographer to VRE for unlimited reproduction of photographic documentation.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 33 00**Submittal Procedures****PART 1 - GENERAL****1.01 SUMMARY**

Section includes general requirements and procedures for preparing and transmitting data to the Construction Manager for informational purposes or for review. Other requirements for submittals may be specified under applicable sections of these Specifications. This Section includes procedures for submittal of general items such as:

- A. Shop Drawings
- B. Coordination Drawings
- C. Product Data
- D. Samples
- E. Material Certificates
- F. Welding Certificates
- G. Qualification Data
- H. Installer Certificates
- I. Manufacturer Certificates
- J. Test Reports
- K. Manufacturer's Instructions
- L. Manufacturer's Field Reports

1.02 RELATED SECTIONS

- A. Section 01 31 00 – Project Management and Coordination
- B. Section 01 33 00 – Construction Progress Documentation
- C. Section 01 77 00 – Closeout Procedures
- D. All Technical Specifications provided as part of the Contract Documents.

1.03 DEFINITIONS

Action Submittals: Written or graphic information and physical samples that require review and responsive action by either the CM or the Engineer.

Informational Submittals: Written or graphic information and physical samples that do not require review and responsive action by the CM or the Engineer. Informational Submittals may be rejected for not complying with requirements.

1.04 SUBMITTAL SCHEDULE

- A. The Contractor shall submit an electronic and/or hard copy of the schedule of submittals, for review and approval by the CM, in tabular format arranged in chronological order by dates required per construction schedule within seven (7) days following Notice to Proceed, or prior to any other submittals being sent to the CM for review, whichever date is earlier. Each submittal item on the schedule shall include, but is not limited to, the following:
 - 1. Specification Section number and title
 - 2. Submittal item number and descriptive title
 - 3. Submittal category (action or informational)
 - 4. Scheduled date for submittal
 - 5. Anticipated reviewer (Engineer, CM, or VRE)
 - 6. Scheduled date for final approval
- B. The Contractor may consult with the CM if additional information is needed to prepare the schedule of submittals.

1.05 GENERAL PROCEDURES

- A. General
 - 1. CM will provide electronic copies of CADD electronic files of the Contract Drawings for Contractor's use in preparing submittals.
 - 2. Use of CADD files is at the Contractor's own risk and in no way alleviates Contractor's responsibility for the Work to conform to the Plans and Specifications.
 - 3. The use of Contract Drawings as shop drawings is not permissible.
- B. Processing Time
 - 1. Allow enough time for submittal review, including time for re-submittals, as follows. Time for review shall commence on CM's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including re-submittals.
 - a. Initial Review: Allow 30 calendar days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. CM will advise Contractor when a submittal processed must be delayed for coordination.
 - b. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
 - c. Re-submittal Review: Allow 30 calendar days for review of each-resubmittal.

- d. No extension of the Contract Time will be authorized because of failure to transmit submittals to CM enough in advance of the Work to permit processing. Processing of incomplete or unacceptable submission by the CM shall not reduce the number of calendar days specified above for CM review. Resubmissions shall be treated the same as initial submissions relative to review time. CM cost for processing a submittal requiring more than two submissions due to incomplete or unacceptable submissions by the Contractor shall be the responsibility of the Contractor.
 - e. Notations on submittals that increase the Contract cost or time of completion shall be brought to the CM's attention before proceeding with the Work.
- C. Contractor's Responsibilities: Contractor is responsible for the scheduling and submission of all submittals. Submit to the CM all submittal, the CM will in turn forward submittals to the appropriate parties for review.
- D. Identification: Place a permanent label or title block on each submittal for identification.
- 1. Indicate name of firm or entity that prepared each submittal on label or title block.
 - 2. Provide a space approximately 6 by 8 inches on label or beside title block to record Contractor's review and approval markings and action taken by the CM and Engineer.
 - 3. Include the following information on label for processing and recording action taken:
 - a. Contract name and number
 - b. Date
 - c. Name and address of Engineer
 - d. Name and address of Contractor
 - e. Name and address of subcontractor, if applicable
 - f. Name and address of supplier, if applicable
 - g. Name of manufacturer, if applicable
 - h. Submittal number or other unique identifier, including revision identifier
 - i. Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g. 06 10 00.01). Resubmittal shall include an alphabetic suffix after another decimal point (e.g., 06 10 00.01.A)
 - i. Number and title of appropriate Specification Section
 - j. Drawing number and detail references, as appropriate
 - k. Location(s) where product is to be installed, as appropriate
 - l. Transmittal number

- E. Use for Construction: Use only final submittals with mark indicating “approved” by CM in connection with construction.
- F. Distribution: Contractor shall furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers and authorities having jurisdiction and others as necessary for performance of construction activities.
 - 1. Contractor shall bear all costs incurred for such reproduction and distribution. Prints of all reviewed Shop Drawings may be made from transparencies that carry the appropriate review stamps.

G. Submittal Preparation

- 1. Submit one (1) electronic (.pdf) version of all submittals, unless noted otherwise, required by individual Specification Sections and elsewhere in the Contract Documents to the CM.
- 2. A Contractor's transmittal letter shall accompany each submittal. The Contractor's transmittal letter and submittal shall be consecutively numbered and shall clearly and completely describe any variation from the contract requirements.
- 3. A sequential number (Submittal No. 1, 2, 3, etc.) shall be shown on each Shop Drawing submission. Re-submittals will be followed by a revision number (Submittal No. 1.1, 1.2, 2.1, etc.) and handled in the same manner as first submitted.
- 4. Resubmittals shall be submitted in the same format at initial submittals.
- 5. All submittals from subcontractors and suppliers shall be reviewed and approved by the Contractor prior to submittal to the CM. The Contractor's review and approval shall certify that the submittal has been reviewed by the Contractor and that based on his review, it conforms to the contract requirements. Further, the Contractor's approval shall certify that the intended product is compatible with all other products, to which it must integrate and to the overall project.
- 6. If Contractor has not checked the submittals carefully, even though certified as reviewed and approved, submittals shall be returned to Contractor for proper checking before further processing or review by CM regardless of any urgency claimed by Contractor. In such a situation, Contractor will be responsible for any resulting delays to the scheduled Contract completion. Furthermore, VRE may hold Contractor responsible for increased VRE costs resulting from Contractor's failure to comply with the requirements set forth herein.
- 7. Submittals not conforming to the requirements of this specification shall be similarly rejected.
- 8. Coordinate preparation and processing of submittals with performance of construction activities. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.

9. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
10. The CM reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.
11. Unless otherwise acceptable to the CM, submittals shall be submitted as one complete package for each specification section.
12. If submittals show variations from the Contract requirements because of standard shop practice or for other reasons, describe such variations in the letter of transmittal. If applicable, the CM may approve any or all such variations, subject to a proper adjustment in the Contract.

H. Review of Submittals

1. Prepare all submittals sufficiently in advance of construction requirements to permit no less than 30 calendar days for review and appropriate action by the CM.
 - a. The review of Shop Drawings and other submittals by the CM or the Engineer will be for general conformance with the Contract only, and the review shall not be interpreted as a checking of detailed dimensions, quantities, or approval of deviations from the Contract Documents. CM or the Engineer review shall not relieve Contractor of its responsibility for accuracy of Shop Drawings nor for the furnishing and installation of materials or equipment according to the Contract requirements.
 - b. VRE review and acceptance of submittals shall not relieve the Contractor from their responsibility for accuracy of submittals, for conformity of submittals to requirements of Contract Drawings and Specifications, for compatibility of the described product with contiguous products and the rest of the system, or for protection of completion of the Contract in accordance with the Contract Drawings and Specifications.
2. If submittals require approval from the Railroad, the Contractor shall allow an additional 30 calendar days for review.
3. Allow an additional 30 days for review of resubmittals.
4. Action Submittals

The Engineer will review each submittal, make marks to indicate corrections or modifications required, and return it. The Engineer will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action taken, as follows:

- a. No Exceptions Taken: The Work covered by the submittal may proceed provided it complies with requirements of the Contract Documents. Final payment depends on that compliance.

- b. Approved As Noted: The Work covered by the submittal may proceed provided it complies with notations or corrections on the submittal and requirements of the Contract Documents. Final payment depends on that compliance.
- c. Revise And Resubmit: Do not proceed with Work covered by the submittal, including purchasing, fabrication, delivery, or other activity. Revise or prepare a new submittal according to the notations; resubmit without delay.
- d. Rejected: The Engineer has not completed a full review, because it is clear that the submittal does not reflect the requirements of the Contract Documents. Do not proceed with work covered by the submittal, including purchasing, fabrication, delivery, or other activity. Revise or prepare a new submittal that complies with the Contract Documents.

5. Informational Submittals

The CM will review each submittal and will not return it, or will reject and return it if it does not comply with Contract Document requirements.

- I. Partial submittals are not acceptable, will be considered non-responsive, and will be returned without review.
- J. All work in and on the property of VRE or the Railroad, or work, which may affect operations, must be approved by VRE in advance. Where work involves VRE coordination, the Contractor shall submit a description of activities and impacts to VRE with a copy to the CM.
- K. The Contractor shall be responsible for and bear all cost of damages which may result from the ordering of any material or from proceeding with any part of the work prior to the approval by the Engineer of the necessary submittals. VRE may issue a Stop Work Order for noncompliant work or for work that has commenced without an approved submittal.
- L. The Contractor shall distribute copies of approved submittals to manufacturers, subcontractors, suppliers, fabricators, installers, and others as necessary for performance of construction activities.

1.06 **SUBMITTAL LOG**

- A. Prepare a log that contains a complete listing of all submittals required by Contract. Submit the log at the preconstruction meeting along with Contractor's 90-day preliminary schedule specified in Division 01 Section "Construction Progress Documentation." Organize the submittal log by Section number. Assign each submittal a sequential number for identification and tracking purposes.
 - 1. Coordinate the submittal log with Division 01 Section "Construction Progress Documentation." The submittal log shall be submitted for CM's review. Include the following information:
 - a. Title of submittal/description

- b. Submittal number (sequential)
- c. Schedule date for the first submittal
- d. Drawing number, if applicable
- e. Applicable section number
- f. Name of subcontractor/vendor
- g. Schedule date of CM's final release or approval

1.07 ACTION SUBMITTALS

A. Shop Drawings

1. Shop Drawing Preparation

- a. The Contractor shall prepare Shop Drawings as necessary or as required by the Contract to adequately perform the work.
- b. Shop Drawings shall be treated as Submittals and prepared in accordance with the requirements of the General Procedures section of this Specification, unless noted otherwise.
- c. Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:
 - i. Dimensions
 - ii. Identification of products
 - iii. Fabrication and installation drawings
 - iv. Roughing-in and setting diagrams
 - v. Shop work manufacturing instructions
 - vi. Schedules
 - vii. Design calculations
 - viii. Compliance with specified standards
 - ix. Notation of coordination requirements
 - x. Notation of dimensions established by field measurement
 - xi. Relationship to adjoining construction clearly indicated
 - xii. Seal and signature of professional engineer if specified
- d. Submit one (1) electronic (.pdf) version and two (2) printed color copies of Shop Drawings on 22" x 34" paper for review and approval by VRE.
- e. All Shop Drawings shall be to scale on sheets measuring 22" x 34". Each drawing shall have a blank area five inches by five inches adjacent to the title

block to provide space for Contractor and Engineer review stamps. The title block shall display the following:

- i. Contract Number and Name
 - ii. Number and Title of the Drawing
 - iii. Date of Drawing or revision
 - iv. Name of Contractor and Subcontractor submitting drawing
 - v. Clear identification of contents and location of work
- f. Electronic Files of Contract Drawings
- i. If requested, electronic digital data files of the Contract Drawings will be provided by VRE for the Contractor's use in preparing Shop Drawings. The use of Contract Drawings as shop drawings is not permissible.
 - ii. The Engineer makes no representations as to the accuracy or completeness of digital data drawing files as they relate to the Contract Drawings. The accuracy should be verified by the Contractor prior to use for Shop Drawings.
- g. Check and coordinate drawings with the work of all trades involved before they are submitted for the approval of the Engineer. Each drawing shall bear the Contractor's stamp of approval as evidence of such checking and coordination. Drawing submitted without this stamp of approval will be returned to the Contractor for resubmittal.
- h. Unless directed otherwise, all hard copies of Shop Drawings shall be sent to the CM directly from the Contractor, not from Subcontractors, fabricators or suppliers.
2. Engineer Review of Shop Drawings
- a. If approved, or approved as noted, by the Engineer, each sheet of the drawing set will be identified as having received such approval by being stamped as such.
 - b. Drawings that require corrections will be returned to the Contractor for correction and resubmittal. The Contractor shall make corrections required by the Engineer.
 - c. Following approval from the Engineer, the Contractor shall provide one (1) electronic (.pdf) version and two (2) printed color copies of Shop Drawings to the Engineer on 22" x 34" paper for field use. Field Use Drawings shall be provided to the Engineer prior to commencement of Work related to the Shop Drawings.
 - d. Engineer approval of Shop Drawings shall not be construed as:
 - i. Permitting any departure from the Contract requirements.

- ii. Relieving the Contractor of the responsibility for any errors, including details, dimensions, and materials.
- iii. Approving departures from details furnished by the Engineer, except as otherwise provided herein.
- iv. Notice to Proceed on a change to the contract that would result in additional time or cost to VRE.

B. Coordination Drawings

- 1. Coordination Drawings are Shop Drawings prepared by Contractor that detail the relationship and integration of different construction elements that require careful coordination during fabrication or installation. Preparation of Coordination Drawings is specified in Division 01 Section 01 31 00 "Project Management and Coordination."
- 2. Submit Coordination Drawings for integration of different construction elements. Show sequences and relationships of separate components to avoid conflicts in use of space.

C. Product Data

- 1. Submit one (1) electronic (.pdf) version of all Product Data submittals to the Engineer for review and approval.
- 2. Mark product data sheets to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information unique to this Project.
- 3. Identify options requiring selection by the Engineer.
- 4. Catalog cuts (product data) shall highlight the actual equipment/component to be used. Generic catalog cuts will not be accepted.

D. Product Samples

- 1. The Contractor shall submit Samples as necessary or as required by the Contract to adequately perform the work.
- 2. Samples shall be treated as Submittals and prepared in accordance with the requirements of the General Procedures section of this Specification, unless noted otherwise.
- 3. Deliver two (2) identical samples to the Construction Manager or location designated by the Construction Manager, for review and approval. Enclose a printed copy of the submittal documentation with the shipment of samples and send one (1) electronic (.pdf) copy of the submittal package to the Engineer, including photographic documentation of the sample.
- 4. Label each sample indicating:
 - a. Name of Project and Contract Number

- b. Name of Contractor and Subcontractor
 - c. Material or equipment represented
 - d. Name of producer and brand; include model number, style, color name, etc. if applicable.
 - e. Specification Section, Article or Paragraph
 - f. Location in project where product is to be utilized
5. Samples for Initial Selection
- Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.
6. Samples for Verification
- Submit full-size units or Samples of size indicated, prepared from the same material to be used for the Work, cured and finished in manner specified, and physically identical with the product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.
7. Submit Samples for review of kind, color, pattern, and texture for a final check of these characteristics with other elements and for a comparison of these characteristics between final submittal and actual component as delivered and installed.
- a. If variation in color, pattern, texture, or other characteristic is inherent in the product represented by a Sample, submit at least three sets of paired units that show approximate limits of the variations.
 - b. Refer to individual Specification Sections for requirements for Samples that illustrate workmanship, fabrication techniques, and details of assembly, connections, operation, and similar construction characteristics.

1.08 INFORMATIONAL SUBMITTALS

- A. Submit one (1) electronic (.pdf) version of all Informational Submittals to the Engineer for information only, as required by individual Specification sections.
- B. Request for Information
 - 1. Refer to Division 1 Section 01 31 00, "Project Management and Coordination" for additional requirements.
- C. Material Certificates
 - 1. Prepare written statements on manufacturer's letterhead certifying that material complies with requirements.

D. Welding Certificates

1. Prepare written certification that welding procedures and personnel comply with requirements. Submit record of Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) on AWS forms. Include names of firms and personnel certified.

E. Qualification Data

1. Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, names and addresses of project owners, and other information specified.

F. Installer Certificates

1. Prepare written statements on manufacturer's letterhead certifying that Installer complies with requirements and, where required, is authorized for this specific Project.

G. Manufacturer Certificates

1. Prepare written statements on manufacturer's letterhead certifying that manufacturer complies with requirements. Include evidence of manufacturing experience where required.

H. Material Test Reports

1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements.

I. Preconstruction Test Reports

1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements.

J. Compatibility Test Reports

1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

K. Field Test Reports

1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements.

L. Product Test Reports

1. Prepare written reports indicating current product produced by manufacturer complies with requirements. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

M. Manufacturer's Instructions

1. Prepare written or published information that documents manufacturer's recommendations, guidelines, and procedures for installing or operating a product or equipment. Include name of product and name, address, and telephone number of manufacturer. Include the following, as applicable:
 - a. Preparation of substrates
 - b. Required substrate tolerances
 - c. Sequence of installation or erection
 - d. Required installation tolerances
 - e. Required adjustments
 - f. Recommendations for cleaning and protection
 - g. Conflicts between manufacturers' instructions and Contract Documents

N. Manufacturers Field Reports

1. Prepare written information documenting factory-authorized service representative's tests and inspections. Include the following, as applicable:
 - a. Name, address, and telephone number of factory-authorized service representative making report.
 - b. Statement on condition of substrates and their acceptability for installation of product.
 - c. Statement that products at Project site comply with requirements.
 - d. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
 - e. Results of operational and other tests and a statement of whether observed performance complies with requirements.
 - f. Statement whether conditions, products, and installation will affect warranty.
 - g. Other required items indicated in individual Specification Sections.

1.09 ADDITIONAL SUBMITTALS

- A. When additional submittals are required, by VRE, they shall be submitted within ten (10) days of receipt of written notification, unless otherwise requested by the Contractor and approved by the CM in writing.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 35 13**Host Railroad Coordination****PART 1 - GENERAL****1.01 SUMMARY**

Section includes requirements for coordinating construction operations on Host Railroad Property including, but not limited to, the following:

- A. Host Railroad safety requirements
- B. Host Railroad train operations
- C. Flagging protection
- D. Daily job briefing
- E. Contractor work hours

1.02 RELATED SECTIONS

- A. Section 01 35 23 – Safety and Security Requirements
- B. Section 01 50 00 – Temporary Facilities and Controls

1.03 DEFINITIONS

Employee-In-Charge (EIC): A designated roadway worker qualified on Operating and On-Track Worker Rules and physical characteristics who is responsible for all movements and on-track safety for a roadway work group within working limits. The employee-in-charge is sometimes referred to as a “flagman.” **Note:** different Host Railroads may refer to this individual by slightly varying names which may include Roadway Worker in Charge (RWIC), “Flagman”, or other.

1.04 HOST RAILROAD SAFETY REQUIREMENTS

- A. If the Project or any part of the Project is located on Host Railroad property, the Contractor must adhere to all Host Railroad safety and general conduct requirements. See Section 01 35 23 – Safety and Security Requirements for additional details.
- B. All procedures and requirements of Host Railroad (whether CSX, Norfolk Southern, or Amtrak) must be adhered to by the Contractor at all times.

1.05 HOST RAILROAD TRAIN OPERATIONS

- A. The safety and continuity of rail operations is of the utmost importance and shall be, in addition to the safety of personnel, the most important consideration at the project site. Contractor shall arrange work so that trains and Host Railroad facilities will be protected and safeguarded at all times.
- B. If the tracks or other facilities of the Host Railroad are endangered during the work, the Contractor shall immediately comply with instructions from the Host Railroad to restore the tracks and facilities to a safe condition. If the Contractor fails to comply, VRE and the Host

Railroad will take whatever actions are necessary to restore safe conditions. The cost for restoring safe conditions or for repairing damage to the Host Railroad's trains, tracks or other facilities caused by the Contractor's operations shall be paid by the Contractor. This cost may be deducted from payment owed to the Contractor.

- C. The method, sequence, and time schedule of performing work which affects the safety and movement of trains shall be approved by the Host Railroad. The Contractor shall remain responsible for all damage to the Host Railroad, its employees, and any other injured party by these acts or those of its employees.
- D. The Contractor shall coordinate its daily work with the Host Railroad in order to protect Host Railroad traffic and construction. The Contractor shall give the Host Railroad sufficient advance notice to ensure that the necessary arrangements for protection of Host Railroad operations are made. No claims may be made against the Host Railroad for delays or any other interference that may delay the Contractor's operations.
- E. The Contractor shall conduct their work so that the scheduled train speeds can be maintained unless permission is received from the Host Railroad for operations that require a reduced speed.
- F. The responsibility for cooperation between the Host Railroad and the Contractor in the maintenance of Host Railroad traffic will be entirely upon the Contractor, and no claims may be made against the Host Railroad or VRE for delays or any other interference that may have caused the Contractor's operations to be delayed in connection with any work under the contract.

1.06 RAILROAD FLAGGING PROTECTION SERVICES

- A. The Contractor must conduct its work so as not to interfere with the operation of the Host Railroad.
- B. Contractor shall not be responsible for costs associated with flagging protection.
- C. The purpose of an EIC is to protect the Host Railroad's train operations from the Contractor's activities occurring on the project. It will be left to the sole discretion of the Host Railroad when an EIC is necessary.
- D. Generally, one or more EICs will be required where a track is/or may be adversely affected by the Contractor's equipment and/or personnel. A track is generally considered to be adversely affected when personnel and/or equipment are within twenty-five (25) feet of the centerline of the track. (Please note: As an example: A crane with a one hundred (100) foot boom operating eighty (80) feet from the centerline of the track will adversely affect the track, i.e. - boom failure).
- E. When an EIC is required, VRE will initially arrange for the EIC to provide protection for the project. Once assigned to the project, the Contractor will be responsible for coordinating the daily schedule with the EIC.
- F. The EIC will contact Contractor's designated employee (i.e.: supervision, foreman, gang watchman) at the site regarding their activity. The Contractor's designated employee is

responsible for protecting the Contractor's workers at the site and ensuring the contractor's activities do not interfere with the safe movement of trains.

If the EIC does not show up at the work site, the Contractor will not do any work that will foul the track. The Host Railroad should be contacted to resolve the situation.

- G. When the Host Railroad has designated certain activities to require an EIC, the Contractor must plan their work at least one week in order for the Host Railroad to make arrangements for the EIC and necessary notifications to the Host Railroad's Transportation Department.
- H. If any incident should occur involving a train operating through the project site, the Contractor should immediately notify the EIC and/or the Host Railroad's representative assigned to the Project so that appropriate action can be taken.
- I. The Contractor shall furnish and maintain in working order, at their expense, two-way radios capable of talking from one end of the Project to the other. Provide radios with a minimum of 5 watts transmitting power. Select the frequency utilized for these transmissions and submit to the CM for approval in writing. Frequencies shall not conflict with or overlay any host railroad operations radio frequencies. These radios shall be utilized by the Contractor and the EIC for the purpose of clearing the Contractor's forces from an approaching train.

1.07 DAILY JOB BRIEFING

- A. A daily job briefing is a short-detailed discussion covering the specifics of the job activities planned for the day.
- B. The Contractor shall conduct a job briefing before the start of work each day. The briefing should include an explanation of all tasks planned for the day, including specific locations on the project and equipment to be utilized if it may foul the tracks.
- C. All Contractor personnel (including subcontractors) expected to perform work on the site that day, shall be in attendance at the job briefing. If a Contractor employee arrives to the site for work after the job briefing is held, another job briefing must be held between said employee, the Contractor's supervisor, and the EIC.
- D. The EIC at the site shall be included in the job briefing. The EIC will explain the type of track protection provided to the Contractor, including limits of protection, available hours for work that day, and other pertinent information relating to the Host Railroad.
- E. All instructions shall be issued clearly and concisely. The Contractor shall ensure instructions are understood by all employees.
- F. The daily job briefing can be performed in conjunction with the Contractor's daily safety meeting. See Section 01 35 23 – Safety and Security Requirements for daily safety meeting requirements.

1.08 CONTRACTOR WORK HOURS

- A. Scheduled work hours shall be discussed during the pre-construction conference. If, during the time discussed, the Contractor is not prepared, has plausible and logical work-arounds, or does not lose time, compensation shall not be allowed.

- B. Expected rail traffic during scheduled work hours shall be discussed during pre-construction conference.
- C. Railroad operations are not necessarily subject to schedules, trains may operate at any time on any track and historical patterns are no indication of future movements and the Contractor must arrange all work accordingly.
- D. When working on the Host Railroad Right-of-Way, Contractor is working under a Construction Agreement between VRE and the Host Railroad. Right of entry and flagging protection services are provided under the noted construction agreement at the discretion and dependent upon the availability of the Host Railroad.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 35 23**Safety and Security Requirements****PART 1 - GENERAL****1.01 SUMMARY**

Section includes requirements for safety and security including, but not limited to, the following:

- A. VRE safety & security requirements
- B. Railroad safety & security requirements
- C. General construction safety & security requirements

1.02 RELATED SECTIONS

- A. Section 01 35 13 – Railroad Coordination
- B. General Provisions
- C. VRE Critical Safety Roles for VRE Projects

1.03 SAFETY REQUIREMENTS

- A. The goal of VRE is to provide a safe and healthy worksite with zero accidents and injuries and no property damage or loss. In addition to the safety and security requirements included in this document, the Contractor shall abide by the Critical Safety Roles for VRE Projects included as an Attachment to the Invitation for Bid (IFB).

Where conflicts or discrepancies exist between requirements, the more stringent requirement shall govern.

1.04 SUBMITTALS

- A. Contractor's Site Specific Safety Plan
 - 1. Contractor shall complete and submit one (1) electronic (.pdf) version of the Contractor's Site Specific Safety Plan, to VRE, for review and approval, no later than seven (7) calendar days prior to the scheduled date of the Preconstruction Conference. Once approved by VRE, the Contractor shall submit two (2) hard copies of the plan in a three-ring binder with a proper cover sheet, labels, table of contents, and tabbed dividers as necessary to ensure the document is reader-friendly.
 - 2. Additionally, the Contractor shall provide original signature of Page 2, included in the "Rules to Live By" attachment for each employee who will access VRE property. VRE's Rules to Live By can be found at VRE Webpage- <https://www.vre.org/safety/safety-initiatives/contractors/>
 - 3. The VRE Site Specific Safety Plan Template is included as an Attachment of the IFB.

B. Monthly Safety Reports

The Contractor shall provide monthly safety reports to VRE, for information only, written by the Contractor's safety manager assigned to the project. The report shall be submitted to VRE along with the Contractor's monthly Application for Payment. The monthly safety report can be combined with the monthly Construction Report, if desired. The monthly safety report shall include, but not be limited to, the following information:

1. Project name & location (City/County and State)
2. VRE contract number
3. Contractor's name
4. Reporting period (shall always be the calendar month)
5. List of subcontractors that performed work on the project during the reporting period
6. Brief description of work performed during the reporting period, including specific locations on the project
7. A list of all safety incidents encountered during the reporting period, noting the type of incident, such as:
 - a. Recordable Injuries or Illnesses as defined by OSHA as death, loss of consciousness, days away from work (lost time), restricted work activity or job transfer (light duty), or medical treatment beyond first aid
 - b. First Aid Injuries or Illnesses
 - c. Near Miss Incident, defined by OSHA as an incident in which no property was damaged and no personal injury was sustained, but where, given a slight shift in time or position, damage or injury easily could have occurred
8. The official reports prepared by the Contractor for each safety incident shown on the list
9. A list of all safety violations noted or suggestions shared with Contractor employees and a description of actions taken to address the issue
10. An update for any incidents/violations encountered in prior months but not yet closed out

C. Contractor Safety Briefing Documentation

The Contractor shall submit to VRE, for information only, a record of daily safety briefings held at the site prior to beginning work each day. Written documentation of the daily safety briefings (VRE Jobs & Safety Briefing Guide) shall be submitted to VRE on a monthly basis along with the Contractor's monthly Application for Payment. A separate document shall be provided for each day the Contractor is on the site. The VRE Jobs & Safety Briefing Guide can be found at VRE Webpage- <https://www.vre.org/safety/safety-initiatives/contractors/>.

1.05 SAFETY PERSONNEL

- A. The Contractor shall provide, or cause to be provided, all technical expertise, qualified personnel, equipment, tools, and material to safely accomplish the Work specified to be performed by the Contractor and subcontractor(s).
- B. At a minimum, the Contractor shall provide the services of at least one full-time on-site Contractor Safety Manager, per construction work shift, for the duration of this Contract, with no other duties assigned, whenever the overall project value exceeds \$5,000,000 or whenever work includes one or more of the following:
 - 1. Bridge work above tracks
 - 2. Tunnel work below tracks
 - 3. Cranes and rigging where required crane capacity is greater than 50-tons
 - 4. Confined space entry
 - 5. Excavations greater than 4-feet

The Contractor shall identify to VRE, a competent, qualified, and authorized Safety Manager on the worksite and who is, by training or experience, familiar with policies, regulations and standards applicable to the work being performed.

- C. The Safety Manager (SM) shall be responsible for the safety and security requirements as indicated herein.
 - 1. The competent, qualified and authorized person must be capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to employees, shall be capable of ensuring that applicable safety regulations are complied with, and shall have the authority and responsibility to take prompt corrective measures, which may include removal of the Contractor's personnel from the work site or holding or stopping specific work activities to remedy safety issues.
- D. The Contractor shall submit the résumés of individual(s) proposed to serve in the role of the Contractor's Safety Manager to the CM for approval in writing. Résumés shall include but not be limited to such items as: work experience, education, safety and health training completed, memberships in professional associations, professional certifications, professional registrations and professional references confirming the qualifications and personal references of contacts for verification shall also be required.
 - 1. The SM will be interviewed by the VRE PM and the CM. The VRE PM and CM will assign written approval of the Safety Manager. Only qualified personnel will be approved. On-site work may not be performed until the Safety Manager is approved and present on-site.
- E. Qualifications: The SM must be a full-time on-site position with one of the following qualifications:
 - 1. Minimum of ten years of safety management experience in managing safety programs on large construction projects comparable to this Contract in scope and complexity.

2. A Certified Safety Professional (CSP) or a Licensed Professional Engineer (PE) with a minimum of five years of experience in railroad construction safety supervision.
- F. For contracts with exposure to the Railroad, the Safety Manager must have at least one-year experience in a railroad environment unless approved by the CM, taking into consideration the proximity of the project to railroad tracks.
- G. Prior to start of construction activities on Railroad Operating Environment/Worksite, the Contractor's Safety Manager shall tour the portions of the worksite affected by this work with VRE's Chief Safety Officer, or designee.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 42 00**References, Definitions, Abbreviations, and Acronyms****PART 1 - GENERAL****1.01 SUMMARY**

Section includes definitions of many of the general terms, abbreviations, and acronyms utilized in these Specifications and other Contract Documents. Additional definitions, specific to certain subjects, can be found in those subject specification sections.

Abbreviations, where not defined in the Contract Documents, will be interpreted by VRE to mean the normal construction industry terminology.

1.02 RELATED SECTIONS

01 25 00 – Substitution Procedures

01 26 00 – Change Order Procedures

01 29 00 – Payment Procedures

01 31 00 – Project Management and Coordination

01 32 00 – Construction Progress Documentation

01 33 00 – Submittal Procedures

01 35 13 – Host Railroad Coordination

01 73 00 – Execution of Work

01 77 00 – Closeout Procedures

All Technical Specifications provided as part of the Contract Documents.

1.03 DEFINITIONS

Certain terms used in the Contract Documents are defined generally in this Specification and the Conditions of the Contract. Definitions and explanations contained in this Section are not necessarily either complete or exclusive but are general for the Work to the extent that they may not be stated more explicitly in another element of the Contract Documents.

Agreement: The completed and signed Form of Contract Agreement

Approve: The term "approved," where used in regard to the CM's action on Contractor's submittals, applications, and requests, is limited to CM's duties and responsibilities as delegated by the Contracting Officer in the Contract and Special Provisions.

Authority Having Jurisdiction (AHJ): An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an

installation, or a procedure. For the majority of VRE projects, the local (County or City) government is the AHJ.

Change Order: A written order signed by VRE to incorporate changes, alterations, or other modifications to the Contract. A Change Order may be used to add, modify, or delete: pay items, Contract time, Contract Documents, or other terms of the Contract. Change Orders may be issued on a bilateral or unilateral basis. The term change order shall be understood as Bilateral Change Order, except where specifically noted as a Unilateral Change Order.

Bilateral Change Order: A written change order signed by both VRE and the Contractor where VRE and the Contractor agree upon the scope, the cost, and the time adjustment for the proposed change, alteration, or other modification to the Contract. This type of change order is what is typically meant when the term change order is used elsewhere in VRE publications.

Proposed Change Order (PCO): A document prepared by the Contractor requesting changes, alterations, or other modifications to the Contract, such as to add, modify, or delete: pay items, Contract time, Contract Documents, or other terms of the Contract. Once a PCO has been accepted by VRE, it becomes a Change Order and will be incorporated into the Contract via a Contract Amendment. Several PCOs may be combined into one Change Order, as determined by the Contract Manager.

Unilateral Change Order: A written change order signed only by VRE used to effect a change, alteration, or other modification to the Contract when VRE and the Contractor cannot agree upon the scope, the cost, or the time estimation of the proposed change, alteration, or other modification to the Contract or where due to issues of emergency, safety, environmental damage, or other similar critical factors VRE must act quickly and unilaterally to effect the change. In these cases, VRE must act unilaterally to establish a scope, cost, or time adjustment for, the change, alteration, or other modification to the Contract.

Claim: The Contractor's written request or demand for an adjustment to the Contractor's compensation or to the Contract time, for costs, expenses, or other damages, adjustment of the Contract terms, or for any entitlement available under the Contract, made within the time, in the form, and pursuant to the provisions for claims specified in the Contract Documents.

Construction Manager (CM): The firm or individual designated by VRE to manage the Contract on behalf of VRE. The Construction Manager is VRE's authorized representative for specific purposes to perform specified duties and responsibilities, and to have the rights and authorities as assigned in connection with completion of the Work in accordance with the Contract Documents, until such time as VRE may notify the Contractor otherwise. The Construction Manager, in conjunction with the Inspector, will monitor the Work for compliance with the Contract Documents.

Construction Schedule: See Section 01 32 00, "Construction Progress Documentation," for details and terms specific to the Construction Schedule.

Contract Amendment: A change order which has been accepted by VRE, processed, and executed by way of signature by both the Contractor and VRE.

Contract Documents: Documents containing the requirements of the Work. They include, the Agreement and all the documents and Exhibits identified therein which shall include the Invitation for Bid (IFB) Documents, Drawings, Specifications, and all modifications including amendments and subsequent Change Orders thereto properly incorporated in the Contract. These include all Contract provisions and attachments made thereto or referenced therein.

Contractor: The business that has a direct contract with VRE, which is in writing and signed by VRE, to perform the prescribed Work as an independent contractor. The Contractor may also be referred to as the General Contractor or the Prime Contractor.

Drawings: Installation/construction plans, or any other supplementary plans or similar graphic data, illustrating work to be performed that are provided to Contractor as part of the Contract Documents. All drawings pertaining to the Contract, including the Contract Drawings and Construction Notes which show and describe the locations, character, dimensions, and details of the Work to be performed under the contract.

Engineer of Record: The firm or individual responsible for preparation of the Drawings, Specifications, and other Contract Documents. May also be referred to as "Engineer."

Final Completion: The condition when VRE agrees that all the Work has been fully completed in accordance with the Contract Documents, all punch list items have been addressed and accepted, final cleaning has been accomplished, all closeout submittals have been received in acceptable condition, demonstration and training of systems has taken place, the VRE Closeout Checklist has been completed, and the final Application for Payment from the Contractor has been reviewed and deemed acceptable by VRE. The date of Final Acceptance is the date of execution by the Contracting Officer of a Certificate of Final Acceptance.

Furnish: Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.

Host Railroad: A railroad that has effective operating control over the segment of track where the Work is to be performed. See Section 01 35 13, "Host Railroad Coordination," for details and terms specific to the Host Railroad.

Indicated: Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown," "noted," "scheduled," and "specified" have the same meaning as "indicated."

Inspector: The Construction Manager's authorized representative who is assigned to make detailed inspections of the quality and quantity of the work and its conformance to the requirements and provisions of the Contract.

Install: Unload, temporarily store, unpack, assemble, erect, place, anchor, apply, work to dimension, finish, cure, protect, clean, and similar operations at Project site.

Notice of Award: The Date of Execution of the Agreement by the VRE Manager of Contract Administration.

Notice to Proceed (NTP): A written notice issued by VRE to the Contractor stating the Commencement Date, the date on which the Contract time will commence for the Contractor to begin the prosecution of the Work required under the Contract. The Notice to Proceed will specify the Period of Performance of the Contract.

Owner: The entity that solicits the work and ultimately possesses the completed work. Unless noted otherwise herein, Virginia Railway Express (VRE) shall be considered the Owner.

Period of Performance: The number of consecutive calendar days beginning on the Notice to Proceed date which the Contractor is allotted to complete all the Work required by the Contract. Day number one (1) of the Contract is the date of NTP, unless noted otherwise.

Plans: See Drawings.

Project Manager (PM): The VRE employee responsible for the management of the Contract. A Construction Manager may be designated by the Project Manager to act on behalf of VRE to perform construction services administration, project oversight, or other services as defined by VRE.

Project Site: Space available for performing construction activities. The extent of Project site is indicated in the Drawings.

Provide: Furnish and install, complete and ready for the intended use.

Schedule of Values: A listing of the Contractor's total contract value by Construction Specifications Institute (CSI) divisions, Contract Pay Items, or other breakdown of items as required by VRE. See Section 01 29 00, "Payment Procedures," for details regarding the Schedule of Values.

Specifications: Technical Specifications, Special Provisions, and all written agreements and instructions pertaining to the performance of the Work.

Technical Specifications: The part of the Contract Documents that describe the quality of materials, method of installation, standard of workmanship, and the administrative and procedural requirements for the performance of the Work under the contract.

Special Provisions: The written statements modifying or supplementing the Technical Specifications or General Terms and Conditions for requirements or conditions peculiar to the Contract.

Subcontractor: An individual or business that holds a signed agreement with the Contractor to perform part or all of the Contractor's Work. A second-tier Subcontractor holds a signed agreement with a first-tier Subcontractor to perform part or all of the first-tier Subcontractor's Work.

Submittal: A deliverable required by the Contract Documents, specifically the Technical Specifications, to be prepared by the Contractor and approved by VRE, the CM, or the Engineer of Record to verify the Work will be installed utilizing the correct materials and procedures. See Section 01 33 00, "Submittal Procedures," for details and terms specific to Submittals.

Substantial Completion: The condition when VRE agrees that the Work, or a specific portion thereof, is sufficiently complete, in accordance with the Contract Documents, so that it can be

utilized by VRE for the full use and function for which it was intended, including the issuance of a Certificate of Occupancy, if applicable, and/or Host Railroad acceptance, if applicable. The date of Substantial Completion of the Work under the Contract is the milestone date on which Substantial Completion condition is accomplished. The only remaining physical work shall be the completion of punch list work prior to Final Acceptance.

Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor.

Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.

Substitutions for Convenience: Changes proposed by Contractor or VRE that are not required in order to meet other Project requirements but may offer advantage to the Contractor or VRE but are not considered Value Engineering Proposals.

Superintendent: The Contractor's Project representative who is authorized to receive and fulfill instructions from the PM or CM and who supervises and directs the Work in the field on the Contractor's behalf.

Utilities: Private, county, city, municipal or public facility, structure, or infrastructure, designed, owned and maintained for public use or to provide a public service such as electricity, water, sanitary sewer, storm sewer, drainage culverts, telecommunications, conduits, gas, oil, fiber optics, or cable television.

Work: The services performed under this Contract including, but not limited to, furnishing labor, and furnishing and installing materials and equipment required to complete the project specified in the Contract Documents. Where "as shown," "as indicated," "as detailed," or words of similar import are used, it shall be understood that the direction, requirements, permission, or review of the PM or CM is intended unless stated otherwise. As used herein, "provide" shall be understood to mean "provide complete in place," that is, "furnish and install."

1.04 INDUSTRY STANDARDS

Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.

Publication Dates: Comply with standards in effect as of date of the Contract Documents, unless otherwise indicated.

Copies of Standards: Each entity engaged in construction on Project shall be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents. Where copies of standards are needed to perform a required construction activity, obtain copies directly from publication source and make them available on request.

1.05 ABBREVIATIONS AND ACRONYMS

Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the standards and regulations in the following list. Web site addresses are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.

Abbreviations are also noted on the Contract Plans. If any abbreviation is unknown or unclear the Contractor shall notify the CM or Owner.

INDUSTRY ORGANIZATIONS

AAR	Association of American Railroads
AIA	American Institute of Architects
AMTRAK	National Railroad Passenger Corporation
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASTM	American Society for Testing and Materials International
ATSSA	American Traffic Safety Services Association
CSXT	CSX Transportation, Inc.
NECA	National Electric Contractor's Association
NEMA	National Electric Manufacturers Association
NFPA	National Fire Protection Association
NRTL	National Recognized Testing Laboratory
NS	Norfolk Southern Railway Corporation
NVLAP	National Voluntary Laboratory Accreditation Program
UL	Underwriters Laboratories, Inc.

STANDARDS AND REGULATIONS

CFR	Code of Federal Regulations Available from Government Printing Office
MUTCD	Manual on Uniform Traffic Control Devices Department of Transportation Federal Highway Administration

FEDERAL AGENCIES

FTA	Federal Transit Administration
NIST	National Institute of Standards and Technology U.S. Department of Commerce
OSHA	Occupational Safety & Health Administration

STATE/LOCAL GOVERNMENT AGENCIES

DDOT	District Department of Transportation
DRPT	Department of Rail and Public Transportation
VDEQ	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 45 00**Quality Assurance and Quality Control****PART 1 - GENERAL****1.01 SUMMARY**

- A. Section includes general requirements and procedures for:
 - 1. Conflicting Requirements
 - 2. Submittals
 - 3. Quality Control
 - 4. Quality Assurance
 - 5. Test and Inspection Log
 - 6. Contractor's Quality Management Plan
 - 7. Notification of Non-Compliance
- B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
- C. Specific Quality Assurance and Quality Control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
- D. Specified tests, inspections, and related actions do not limit Contractor's other Quality Assurance and Quality Control procedures that facilitate compliance with the Contract Document requirements.
- E. Requirements for Contractor to provide Quality Assurance and Quality Control services required by the Engineer, Owner, Commissioning Authority (if applicable), or authorities having jurisdiction (as applicable) are not limited by provisions of this Section.
- F. Specific test and inspection requirements are not specified in this Section.

1.02 RELATED SECTIONS

- A. Section 01 33 00 – Submittal Procedures
- B. Section 01 60 00 – Product Requirements
- C. All Technical Specifications provided as part of the Contract Documents.

1.03 DEFINITIONS

- A. **Quality Assurance (QA):** The application of planned and systematic reviews which demonstrate that Quality Control practices are being effectively implemented.

- B. **Quality Control (QC):** The continuous review, certification, inspection, and testing of project components, including persons, systems, services, materials, documents, techniques, and workmanship to determine whether or not such components conform to the plans, specifications, applicable standards, and project requirements. Services do not include contract enforcement activities performed by the Construction Manager.
- C. **Preconstruction Testing:** Tests and inspections performed specifically for the project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria.
- D. **Source QC Testing:** Tests and inspections that are performed at the source, e.g., plant, mill, factory, or shop.
- E. **Field QC Testing:** Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- F. **Testing Agency:** An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
- G. **Installer:** Contractor or another entity engaged by Contractor as an employee or Subcontractor to perform a particular construction operation, including installation, erection, application, and similar operations.
- H. **Experienced:** Unless otherwise indicated in individual Specification sections, when used with an entity or individual, "experienced" means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.04 **CONFLICTING REQUIREMENTS**

- A. If compliance with two standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to the CM for a decision before proceeding.

1.05 **SUBMITTALS**

- A. Contractor's Quality Management (QM) Plan

The Contractor shall submit, for review and approval by VRE, a project specific plan detailing Quality Control and Quality Assurance activities and responsibilities for the Project. Submit one (1) electronic (.pdf) version of the plan. The plan shall be submitted no later than seven (7) calendar days prior to the scheduled date of the Preconstruction Conference. Once approved by VRE, the Contractor shall submit two (2) hard copies of the plan in a three-ring binder with a proper cover sheet, labels, table of contents, and tabbed dividers as necessary to ensure the document is reader-friendly.

- 1. Any approval by the CM of the QM Plan shall be treated as "approved, predicated upon successful implementation." If the CM finds any portion of the QM plan is not being

implemented as approved, CM may issue a stop work order, for any of the portion of work in question.

See detailed requirements for the Quality Management Plan in Article 1.09 of this section.

B. Qualification Data

The Contractor shall submit, for VRE review and approval, qualification data for the Contractor's Quality Control personnel, as specific QC personnel are required by Contract.

C. Testing Agency Qualifications

The Contractor shall submit, for review and approval by VRE, qualifications of the proposed Independent Testing Agency to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority. Rejection of an Independent Testing Agency by the CM or VRE does not constitute grounds for additional monetary compensation to the Contractor.

D. Test and Inspection Reports

Submit test and inspection reports as required in individual technical specification sections.

1.06 QUALITY CONTROL

A. Contractor Responsibilities

1. Perform Quality Control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.
2. Perform tests and inspections not explicitly assigned to VRE or Others. Perform additional Quality Control activities required to verify that the Work complies with requirements, whether specified or not.
3. Unless otherwise indicated, provide Quality Control services specified and/or those required by the Authority Having Jurisdiction (AHJ.)
4. Cooperate with Independent Testing Agency and provide the following:
 - a. Access to the Work
 - b. Incidental labor, facilities, equipment, and tools necessary to facilitate tests and inspections
 - c. Adequate quantities of representative samples of materials that require testing and inspecting
 - d. Facilities for storage and field curing of test samples
 - e. Security and protection for samples and for testing and inspecting equipment at project site
5. Notify the Independent Testing Agency and the CM at least 24 hours prior to expected time for operations requiring testing and inspection services

6. Schedule jurisdictional inspections, including any special inspections, as required by associated permits or building officials
7. Obtain Certificates of Occupancy, if applicable
- B. Should field conditions conflict with Contract Documents, request clarification from the CM before proceeding.
- C. If manufacturer's instructions conflict with Contract Documents, request clarification from the CM before proceeding.

1.07 QUALITY ASSURANCE

A. Independent Testing Agency

1. Where services are indicated as Contractor's responsibility, engage a qualified testing agency to perform these Quality Control services. Contractor shall employ and pay for the services of an independent firm approved by VRE to perform all inspection and testing.
2. The Independent Testing Agency shall be a corporately and financially independent testing organization that can function as an unbiased testing authority, professionally independent of manufacturers, suppliers, and installers of equipment, or systems evaluated by the testing organization shall be contracted by the Contractor to perform the contractually required tests.
3. The Independent Testing Agency shall be a Nationally Recognized Testing Laboratories (NRTL), a National Voluntary Laboratory Accreditation Program (NVLAP), or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E329; and with additional qualifications specified in individual Sections; and, where required by authorities having jurisdiction, that is acceptable to authorities.
 - a. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7
 - b. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program
4. VRE reserves the right to employ a separate Independent Testing Agency (ITA) at its own cost under separate contract. Contractor shall not employ same entity engaged by VRE, if applicable, unless agreed to in writing by VRE.
5. Testing Agency Responsibilities
 - a. Cooperate with VRE, the CM, and the Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
 - b. Perform inspections, tests, and other services specified in individual technical specification sections.
 - c. Determine the location from which test samples will be taken and in which in-situ tests are conducted.

- d. Submit a certified written report of each test, inspection, and similar Quality Control service. Reports shall be submitted by the Independent Testing Agency directly to the CM indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents.
 - i. Report shall cite applicable Contract requirements, tests or analytical procedures used. Provide actual results and include a statement that the item tested or analyzed conforms or fails to conform to specified requirements. If the item fails to conform, notify CM immediately. Conspicuously stamp the cover sheet for each report in large red letters "CONFORMS" or "DOES NOT CONFORM" to the specification requirements, whichever is applicable.
 - ii. A testing laboratory representative authorized to sign certified test reports shall sign test results. Furnish the signed reports, certifications, and other documentation directly to the CM.
 - e. Retesting and reinspection required because of non-conformance to specified requirements shall be performed by the same Independent Testing Agency. The cost for retesting will be borne by the Contractor.
 - f. Notify the CM and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
- B. The Construction Manager has the authority to reject work due to non-compliance with Contract Documents.

1.08 TEST AND INSPECTION LOG

- A. Contractor shall prepare and maintain a record of tests and inspections. Report shall include, but not be limited, to the following:
- 1. Date test or inspection was conducted
 - 2. Description of the Work tested or inspected
 - 3. Date test or inspection results were transmitted to the CM
 - 4. Identification of testing agency or special inspector conducting test or inspection
- B. Contractor shall maintain a log for inspection by the CM, when requested.

1.09 CONTRACTOR'S QUALITY MANAGEMENT PLAN

- A. The Contractor shall prepare a Quality Management Plan for the project which will spell out the policies, processes, and procedures to be used in order to assure the quality of all work and products produced for the project. The Quality Management Plan shall include planned and systematic actions necessary to provide adequate confidence to VRE that construction will satisfy the given requirement for quality. The Federal Transit Administration (FTA) Quality Assurance and Quality Control Guidelines shall be referenced in the preparation of this plan, if the project is fully or partially funded by the FTA.

1. The only work that is authorized to proceed prior to the approval of the QM Plan is mobilization of storage and office trailers, temporary utilities, and surveying.
 2. Approval of the QM Plan is required prior to the start of any construction. The CM reserves the right to require changes in the QM Plan and operations as necessary, including but not limited to removal of personnel, to ensure the specified quality of work. The CM reserves the right to interview any member of the QC organization at any time in order to verify the submitted qualifications. All QC organization personnel shall be subject to acceptance by the CM. The CM may require the removal of any individual for non-compliance with quality requirements specified in the contract.
- B. Notify the CM, in writing, of any proposed change, including changes in the QC organization personnel, a minimum of seven calendar days prior to a proposed change. Proposed changes shall be subject to acceptance by the CM.
- C. The Quality Management Plan shall include a written quality policy, written plan, written procedures, and a management team that supports and takes responsibility for quality and personnel who undertake Quality Control activities. The procedures shall include, at a minimum, the following elements:
1. Management Responsibility
 - a. Personnel Matrix
 - b. Names and Qualifications
 - c. Duties, Responsibilities and Authority of QC Personnel
 2. Document Control Procedures (using PMIS prescribed by VRE)
 3. Subcontracting and Purchasing Procedures
 4. Inspection and Testing
 - a. Testing Laboratory Information and Certifications
 - b. Special Inspections
 5. Procedures for Verification of Materials at Delivery
 6. Procedures for Control of Inspection, Measuring and Test Equipment
 7. Procedures for Reporting, Review and Disposition of Nonconforming Product
 8. Corrective Actions
 9. Procedures for Control of Quality Records
 10. Training
- D. Quality Control Personnel Qualifications
1. Provide sufficient qualified full-time quality control personnel trained and experienced in managing and executing Quality Assurance and Quality Control procedures similar in nature and extent to those required for Project. Personnel shall monitor work activity at

all times. Scheduling and coordinating of all inspections shall match the type and pace of the work activity.

- a. In cases where multiple trades, disciplines, or subcontractors are on site at same time, each activity shall be tested and inspected by personnel skilled in that portion of the work.
 - b. In cases where multiple shifts are employed, the quality-control staff shall be increased as required to monitor the work on each shift.
2. The following position is key personnel as defined by VRE in this and other Division 01 Specification Sections:
- a. Quality Control Manager (QCM)

- i. Duties

Provide a QCM at the work site to implement and manage the Contractor's QC Program. The duties and responsibilities of the QCM is to ensure compliance with the QM Plan. The QCM shall not be designated as the safety competent person as defined by Division 01 Section 01 35 23 "Safety and Security Requirements."

The QCM is required to attend QC planning meetings, conduct the QC meetings, perform submittal review and approval, ensure testing is performed and provide QC certifications and documentation required in this contract. The QCM is responsible for documentation performed by Testing Laboratory personnel and any other inspection and testing personnel required by this Contract.

1. On Projects above \$5,000,000 the only duties and responsibilities of the QCM are to manage and implement the Contractors approved QC Plan on the Contract.
 2. On Projects below \$5,000,000 the QCM may have other shared duties and responsibilities in addition to managing and implementing the Contractors approved QC Plan on the Contract.

- ii. Qualifications

A graduate of a four year ABET accredited college program in one of the following disciplines: Engineering, Architecture, Construction Management, Engineering Technology, Building Construction, Building Science, or approved equivalent experience/certification. Experience shall include a minimum of 5 years' experience as a superintendent, QCM, project manager, project engineer or construction manager on similar size and type construction contracts which included the major trades that are part of this Contract.

The individual shall be familiar with VRE's Safety and Security Guidelines, Host Railroad Safety and Quality Control Requirements and have experience in the areas of hazard identification and safety compliance.

Certifications may include Construction Quality Management courses offered by agencies including but not limited to: Construction Management Association of America (CMAA), Associated General Contractors (AGC), Associated Builders and Contractors (ABC) and the Army Corps of Engineers.

Submit the résumés of individuals proposed to serve in the role of Quality Control Manager to the CM. The QCM shall be interviewed by the CM. The VRE PM and CM will assign written approval to the QC Manager and their designee.

iii. Alternate QCM Duties and Qualifications

Designate an alternate for the QCM at the work site to serve in the event of the designated QCM's absence. The period of absence may not exceed two weeks at one time, and not more than 30 workdays during a calendar year. The qualification requirements for the Alternate QCM shall be the same as for the QCM.

E. Quality Control of Submittal Process

Describe procedures for ensuring compliance with requirements through review and management of submittal process. Indicate qualifications of personnel responsible for submittal review.

F. Testing and Inspection

In the Quality Management Plan, include a comprehensive schedule of Work requiring testing or inspection, including the following:

1. Tests and inspections performed by the Independent Testing Agency
2. Special inspections as required by authorities having jurisdiction
3. Tests and inspections indicated in the Contract Documents as to be performed by VRE or Others

G. Continuous Inspection of Workmanship

Describe the process for continuous inspection during construction to identify and correct deficiencies in workmanship in addition to testing and inspection specified. Indicate types of corrective actions to be required to bring work into compliance with standards of workmanship established by Contract requirements.

H. Monitoring and Documentation

1. Maintain current and complete records of testing and inspection reports including log of approved and rejected results. Include work the Construction Manager has indicated as nonconforming or defective. Indicate corrective actions taken to bring nonconforming work into compliance with requirements. Comply with requirements of authorities having jurisdiction.
 - a. Testing log shall be current and up-to-date and include supporting field test reports, arranged by specification section. Log shall be kept in a 3-ring binder readily available to the CM during normal business hours.

2. Contractor shall maintain current quality control records, on forms acceptable to VRE , of all control activities, production, tests and inspections performed. These records shall include factual evidence that required tests or inspections have been performed, including type and number of tests or inspections involved; results of tests or inspections; nature of defects, causes for rejection, etc.; proposed remedial action; and corrective actions taken. These records shall cover both conforming and defective or deficient features (non-conforming) and shall include a statement that all supplies and materials incorporated into the Work are in full compliance with terms of the Contract.
 - a. Legible copies of these records shall be furnished to CM monthly. The records shall cover all work placed subsequent to the previously furnished records and shall be verified by Contractor's QC Personnel. Contractor shall document tests and inspections as specified in the technical provisions of the Specifications, and these records shall be available for review by the CM throughout the life of the Contract.
3. At a minimum, the QC Personnel shall furnish the signed reports, certifications, and a summary report of field tests at the end of each month to the CM.

1.10 NOTIFICATION OF NON-COMPLIANCE

- A. The CM will notify the Contractor of any detected non-compliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the work site, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, VRE may:
 1. Issue an order stopping all or part of the work until satisfactory corrective action has been taken. The Contractor shall make no part of the time lost due to such stop orders the subject of a claim for extension of time for excess costs or damages.
 2. Repair, replace or otherwise remedy the defective work at the Contractor's expense. Cost incurred by VRE to correct defective work shall be deducted from the total amount due to the Contractor.
 3. Withhold an amount from the payment due the Contractor as may be deemed necessary at the discretion of the CM.
 4. Terminate the Contractor's right to proceed for Default after providing required notice in accordance with the Termination for Default procedures described in the General Provisions.
- B. In cases where the Contractor fails to properly operate, maintain and comply with their Quality Management Plan or the Contract Provisions, VRE may:
 1. Order the Contractor to replace ineffective or unqualified Quality Control Personnel or subcontractors.
 2. Issue an order stopping all or part of the work until acceptable personnel are on site and a new Quality Management Plan is approved by the CM. The Contractor shall make no part

of the time lost due to such stop orders the subject of claim for extension of time for excess costs or damages.

3. Take a credit from the contract for Quality Control Activities not performed.
 4. Terminate the Contractor's right to proceed for Default after providing required notice in accordance with the Termination for Default procedures described in the General Provisions.
- C. The Contractor shall maintain a detailed record of every non-compliance and corrective action taken.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 50 00**Temporary Facilities and Controls****PART 1 - GENERAL****1.01 SUMMARY**

A. This section specifies the general requirements for furnishing, installing, and operating temporary facilities and controls. This Section includes:

1. Submittals
2. Compliance
3. Materials
4. Equipment
5. Installation
6. Construction Manager's Temporary Field Office
7. Contractor's Temporary Field Office
8. Contractor Personnel Parking
9. Temporary Utility Service
10. Temporary Sanitary Facilities
11. Project Identification Signage
12. U.S. Department of Labor Signage
13. Maintenance of Traffic (Roadway)
14. Construction Operations Under Railroad Traffic
15. Work, Staging and Storage Areas
16. Termination and Removal

1.02 RELATED SECTIONS

- A. Section 01 29 00 – Payment Procedures
- B. Section 01 33 00 – Submittal Procedures

1.03 SUBMITTALS

- A. Shop Drawings: Submit to CM, for VRE's review and approval, site plans indicating all temporary facilities, including support and security; utility connections and traffic flows. Provide detailed drawings of utility connections and special facilities. Submittals shall include detailed list of materials for use and related specification.
- B. Implementation and Termination Schedule: Within 15 calendar days of date established for submittal of Contractor's first Construction Schedule, submit a schedule indicating implementation and termination of each temporary facility.

1.04 COMPLIANCE

- A. Regulations: Comply with industry standards and applicable laws and regulations of authorities having jurisdiction, including but are not limited to, the following:
 - 1. Building Code requirements.
 - 2. Host Railroad.
 - 3. Health and safety regulations.
 - 4. Police and Fire Department regulations.
 - 5. Environmental protection regulations.
 - 6. All temporary facilities shall be ADA compliant.
- B. Standards: Comply with ANSI A10.6, NECA's "Temporary Electrical Facilities,"
 - 1. Trade Jurisdictions: Assigned responsibilities for installation and operation of temporary utilities are not intended to interfere with trade regulations and union jurisdictions.
 - 2. Electrical Service: Comply with NECA, NEMA, and Underwriters' Laboratory (UL) standards and regulations for temporary electrical service. Install service to comply with NFPA 70.
- C. Tests and Inspections: Arrange for applicable utility service provider to test and inspect each temporary utility before use. Coordinate with applicable utility service provider for requirements for certifications, permits, and inspections. Obtain permits from applicable utility service for temporary construction and temporary utilities.

1.05 MATERIALS

- A. General: Provide new materials. Undamaged, previously used materials in serviceable condition may be used if approved by CM. Provide materials suitable for use intended.

1.06 EQUIPMENT

- A. General: Provide new equipment suitable for use intended. If acceptable to CM, undamaged, previously used equipment in serviceable condition may be used.
- B. Temporary Facilities/Field Offices: Prefabricated or mobile units with lockable entrances, operable windows, and serviceable finishes; heated and air conditioned; on foundations adequate for normal loading and provided with proper tie-downs.
- C. Drinking-Water Fixtures: Containerized, tap-dispenser, bottled-water drinking-water units, including paper cup supply.
 - 1. Where power is accessible, provide electric water coolers to maintain dispensed water temperature at 45 to 55 deg F.
- D. Electrical Outlets/Receptacles: Properly configured, NEMA-polarized outlets that will prevent insertion of 110v or 120v receptacles into higher-voltage outlets and equipped with ground-fault circuit interrupters with reset button.

- E. Self-Contained Toilet Units: Single-occupant units of chemical, aerated re-circulation, or combustion type; vented; fully enclosed with a glass-fiber-reinforced polyester shell or similar nonabsorbent material.
- F. Fire Extinguishers: Hand carried, portable, UL rated with class and extinguishing agent as required by locations and classes of fire exposures.
- G. Heating and Cooling Equipment: Unless CM authorizes use of permanent heating system, provide temporary heating units with individual space thermostatic control.
 - 1. Use of gasoline-burning space heaters, open-flame heaters, or salamander-type heating units is prohibited.
 - 2. Heating and Cooling Units: Listed and labeled, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use for type of fuel being consumed. If liquid fuel is used, provide under-unit containment in the event of leakage. Provide adequate ventilation or direct vent the units top the outside.

1.07 INSTALLATION, GENERAL

- A. Prior to installation of temporary facilities and utilities, submit to the CM a site layout providing locations and details of the facilities and utilities.
- B. Use qualified personnel for installation of temporary facilities.
- C. Provide each facility ready for use when needed to avoid delay. Maintain and modify as required. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

1.08 CONTRACTOR'S TEMPORARY FIELD OFFICE

- A. The Contractor shall provide a mobile unit FOR THE CONTRACTOR on the Project site complete with parking facilities, hereinafter called field office. The field office shall be situated in the work area at an approved location. The field office shall be complete as specified and ready for occupancy by the Contractor within fourteen (14) calendar days after receipt of Notice to Proceed. It shall be maintained and serviced by the Contractor as hereinafter specified until 60 days following completion of the work. A mobile unit shall have the features specified below.
- B. The Contractor shall obtain and pay all costs for hauling, building, and connection permits. The field office shall be substantially constructed satisfactory to VRE.
- C. All materials shall be good commercial quality. The field office shall provide a minimum of 700 square feet of usable area, with the following additional requirements:
 - 1. Exterior surfaces of buildings and all interior surfaces, other than factory-finished surfaces, shall be painted with two coats of an approved paint of approved color(s). No painting will be required on aluminum or stainless steel surfaces.
 - 2. Exterior walls, ceilings and floors, shall be insulated; interior walls and ceiling surfaces shall be paneled with finished plywood or gypsum wallboard of not less than one-half inch thickness, or other suitable materials.

3. Floors shall be covered with flooring material such as resilient tile or sheet linoleum. Floors shall be constructed to withstand a live load of 125 psf.
 4. One (1) rest room shall be provided, with lavatory, self-contained toilet unit, mirror, soap holder, toilet paper holder, paper towel dispenser, and hot and cold water supply.
 5. Lighting shall be provided to furnish a minimum of 100 foot-candles at desk height uniformly in all areas except rest rooms. Rest rooms shall be provided with adequate lighting.
 6. Duplex electrical receptacles shall be provided around interior walls at approximately ten-foot spacing.
 7. An electric water cooler shall be installed to supply cool drinking water.
 8. At Contractor's cost and expense, install, operate, protect and maintain a temporary Heating and air conditioning system. The system shall have thermostatic control. Systems shall be capable of maintaining office at ambient temperature of 72F.
 9. Water, sewer, and electrical utility connections shall be provided as necessary.
 10. Adequate access from public streets shall be provided to the field office together with adjacent space for parking four (4) cars, for use by the CM and VRE. The access roadway and parking area shall be graded for drainage and surfaced with crushed stone, concrete or bituminous pavement in an approved manner.
 11. The interior of the field office shall provide the following nominal dimensions for partitioned office rooms with doors and locks:
 - a. One (1) at minimum one hundred forty four (144) square feet
 - b. One (1) at minimum one hundred ninety two (192) square feet
 - c. One (1) Conference Room (general area) minimum three hundred sixty (360) square feet
 12. The field office shall also include two (2) exterior doors, 100 square feet of counter space and 200 square feet of shelving arranged as directed by the Construction Manager. Each exterior door shall be equipped with a cylinder lock, mastered keyed alike, and two (2) keys.
- D. The field office shall be provided with the following new furniture and equipment:
1. Four (4) Desks, 60 inches by 30 inches; with one file drawer and four drawers, all with locks; with swivel armchair
 2. Four (4) Folding Tables, 72 inches by 30 inches
 3. Sixteen (16) Folding Side Chairs
 4. One (1) Plan Table, 30 inches by 72 inches, inclined and at height suitable for standing
 5. Four (4) Bookcases, 36 inches by 42 inches, with four shelves
 6. Two (2) Fireproof File Cabinets, legal size, four drawers, with lock

7. One (1) Rolling Plan Storage Rack, twelve-stick
 8. One (1) Utility Cabinet, 18 inches by 46 inches by 30 inches, with lock
 9. One (1) Dry Erase Board, 60 inches by 36 inches
 10. One (1) Refrigerator, minimum 10 cubic feet, frost free
 11. One (1) Microwave, minimum 1000 watts
 12. Four (4) Wastebaskets, small size
 13. One (1) First Aid Kit containing eye and skin protection for emergencies. List telephone number for hospitals and ambulance service in each first aid kit.
 14. Two (2) Fire Extinguishers
 15. One (1) digital multifunction commercial document printer/copier system which shall include color copy, print, and scan functions. The copier shall accommodate, at a minimum, 2 reams of paper sizes 8 ½ x 11 and 11 x 17. The Contractor shall maintain the equipment, provide replacement materials, and any associated software for the duration of this Contract.
- E. Quantities and specifics of the furniture and equipment can be negotiated at the discretion of the Construction Manager, if so requested by the Contractor.
- F. All windows shall be provided with shades, blinds, or curtains and security grills
- G. Maintenance and service shall be provided by the Contractor as follows:
1. Repair and weekly cleaning of the field office, parking area and access road, including complete janitorial services and supplies
 2. The furnishing of all utilities which shall include sewer, water, electric, telephone, and high speed (DSL, cable, or fiber optic) internet connection.
 3. During other than normal working hours, provide security measures and area protection for the Construction Manager's facility equivalent to that used by the Contractor for his job site shop and office facilities, or as approved by VRE.
 4. Provide sufficient area lighting for the Construction Manager's facility, equivalent to that provided by the Contractor for his job site shop and office facilities.
- H. Pest Control: Contractor shall retain a local exterminator or pest-control company to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests. Engage this pest-control service to perform extermination and control procedures at regular intervals so Temporary facilities will be free of pests and their residues at Substantial Completion. Perform control operations lawfully, using environmentally safe materials.
- I. At the completion of this Contract, the complete facility will become the property of the Contractor, who shall remove it and restore the site.

1.09 CONTRACTOR PERSONNEL PARKING

- A. VRE is not responsible for on or offsite parking. Parking facilities for Contractor's personnel shall be the Contractor's responsibility.
- B. Contractor is limited to the construction area as defined in the contract documents. If available, the on-site parking and staging of both company-owned and personal vehicles will be limited to the construction area as defined in the Contract documents. Do not under any circumstances, leave any vehicle unattended with motor running, or with ignition key in-place.
- C. Parking of company-owned and construction personnel's private vehicles at VRE parking lots is prohibited.
- D. If off-site parking is required, Contractor will be responsible for the maintenance, security, safety, and operation of its vehicles/equipment. This cost will be considered part of the Contractor's general conditions. Transportation of personnel to the Work site is the responsibility of the Contractor. Contractor is responsible for the payment of any parking charges or fines resulting from illegal parking at any work site(s). The Contractor shall monitor parking of construction personnel's private vehicles and ensure that the public has unobstructed access to and through parking areas.

1.10 TEMPORARY UTILITY SERVICE

- A. Determine the need for such temporary utility service as may be required to perform the work and make arrangements with utility companies for such service.
- B. The Contractor shall provide temporary electrical service of sufficient capacity to serve its requirements during the life of the Contract. Temporary services shall be furnished, installed, connected, and maintained by the Contractor in an approved manner.
- C. The source of temporary power for testing may be the temporary service, portable generator or other approved system which will deliver power at the voltage and other characteristics required to accomplish testing as specified. Circuits and construction for temporary systems shall suit the needs of the work and comply with NEC (National Electric Code) and the codes and regulations of the jurisdictional authorities and the requirements of VRE.
- D. Remove all materials and equipment involved with temporary utility service as part of final cleanup.
- E. All costs incurred in obtaining permits; utility service, including connection and disconnection; and furnishing, installing, maintaining, and removing such materials as may be required shall be borne by the Contractor.

1.11 TEMPORARY SANITARY FACILITIES

- A. The Contractor shall furnish for use of his work force the necessary temporary toilet conveniences, secluded from public observation, wash facilities and drinking-water fixtures. Keep in a clean, sanitary condition.
 - 1. Disposable Supplies: Provide toilet tissue, paper towels, paper cups, and similar disposable materials for each facility. Maintain adequate supply. Provide covered waste containers for disposal of used material.

2. Toilets: Install self-contained toilet units, located as approved by CM. Shield toilets to ensure privacy. Provide separate facilities for male and female personnel.
 3. Wash Facilities: Install wash facilities supplied with potable water at convenient locations for personnel who handle materials that require wash up. Dispose of drainage properly. Supply cleaning compounds appropriate for each type of material handled.
 - a. Provide safety showers, eyewash fountains, and similar facilities for convenience, safety, and sanitation of personnel.
 4. Drinking-Water Facilities: Provide bottled-water, drinking-water units.
- B. Comply with the requirements and regulations of the local, state, and other agencies having jurisdiction.

1.12 PROJECT IDENTIFICATION SIGNAGE

- A. Provide one sign each for the Construction Manager's Field Office and the Contractor's Field Office to indicate the location of the offices. Use 1/2 or 3/4-inch-thick exterior, A-B grade plywood, cut two (2) feet by four (4) feet long. Paint the sign with one coat of primer sealer and two coats of white semi-gloss enamel. Letter each sign with black enamel paint, using block letters at least four (4) inches high, with the Contract Name, Contract Number and the words VRE/CONSTRUCTION MANAGER'S (or CONTRACTOR'S) FIELD OFFICE painted each on a separate line. Where the field office to be so identified is not readily visible from the project entrance, paint a directional arrow on the sign and locate the sign near the project entrance. The exact location of the field office signs and the proposed method of mounting shall be subject to the approval of the Construction Manager.
- B. Contractor's Identification Signs: The Contractor may erect his own signs to identify himself and, if he wishes, his subcontractors. The overall size of the Contractor's identification signs shall not exceed four (4) feet by eight (8) feet wide. The exact location, method of mounting and mounting height of the Contractor's identification signs will be subject to the approval of the Construction Manager.
- C. Provide other signs as indicated and as required to inform public and individuals seeking entrance to Project.
- D. Provide temporary, directional signs for construction personnel and visitors.
- E. Maintain all signs throughout the course of construction until final acceptance, keeping them clean, in good repair, and free of obstructions.
- F. Upon final acceptance of the work, remove and dispose of all signs, unless otherwise directed by VRE.

1.13 U.S. DEPARTMENT OF LABOR SIGNAGE

The following posters required by the U.S. Department of Labor shall be posted at the construction site, in English and Spanish, in a location visible to all workers:

- A. The Davis-Bacon Act, Poster WH-1321
- B. Equal Employment Opportunity Act, Poster EEOC-P/E-1

- C. Minimum Wage / Fair Labor Standards Act, Poster WH-1088
- D. OSHA Job Safety and Health Protection, Poster OSHA-3165

The required posters can be downloaded and/or purchased from the U.S. Department of Labor website.

1.14 MAINTENANCE OF TRAFFIC (ROADWAY)

- A. If the project is located adjacent to a public street or highway, the Contractor shall have at least one person on the project site during all work operations who is currently verified either by VDOT's Intermediate Work Zone Traffic Control training or by the American Traffic Safety Services Association (ATSSA) Intermediate Traffic Control Supervisor (TCS) training. This person shall be responsible for the oversight of work zone traffic control within the project limits in compliance with the Contract requirements, the VWAPM if the Project is located in Virginia, and the MUTCD. This person's duties shall include the supervision of the installation, adjustment (if necessary), inspection, maintenance, and removal when no longer required, of all work zone traffic control devices on the project.
- B. Certified flaggers shall be provided, by the Contractor, in sufficient number and locations as necessary for control and protection of vehicular and pedestrian traffic in accordance with the VWAPM (Virginia Work Area Protection Manual) and the MUTCD (Manual on Uniform Traffic Control Devices). Flaggers shall be able to communicate to the traveling public in English while performing the job duty as a flagger at the flagger station. Flaggers shall use sign paddles to regulate traffic in accordance with the VWAPM or MUTCD, as applicable.
- C. Employees performing flagging duties shall be certified for such activity by a certification course accepted by VDOT (or local jurisdiction as necessary). Certification cards shall be carried by flaggers while performing flagging duties and presented to the CM or VRE upon request.
- D. The Contractor shall conduct its operations in a manner that will ensure that traffic will be uninterrupted except as approved by VRE. At the close of each work day, the area of work shall be confined to the smallest area possible so that the maximum use of surrounding streets, parking lots, and passenger facilities will be restored and the hazard to pedestrian and vehicular traffic reduced to a minimum. No excavation shall remain open within the roadway, parking lot, or passenger facility without the approval of VRE except when the excavation can be safely bridged with the use of steel plates or other materials acceptable to VRE. When areas of excavation outside of the roadway do remain open, the area shall be barricaded to the satisfaction of VRE and warning signs shall be posted.
- E. At all times the Contractor shall use the personnel and traffic control signs and devices necessary to comply with Part VI of the MUTCD. During the progress of the work when the street may be obstructed to any extent by construction equipment or construction operations, in addition to the signs and barricades, special workers, equipped with "STOP\SLOW" double sided traffic control paddles, shall be designated by the Contractor to direct traffic. These workers so designated shall not be assigned to any other duties while engaged in directing traffic. The Contractor has sole responsibility for ensuring that its operations are conducted in a safe manner.

- F. All costs associated with contractor's personnel, signs, barricades, and any other items necessary for protection of the site and Work, as well as access in and out of the site, either temporary or permanent, shall be the responsibility of the Contractor and included in the base bid for the project.
- G. The MOT plan as implemented in the field during construction of this project shall be as directed, reviewed, and approved by VRE, the Construction Manager, and the AHJ (Authority Having Jurisdiction).
- H. The Contractor shall furnish, install, maintain, and remove when no longer required, all traffic control and protective devices required.
- I. Controls within Railroad right of way are subject to Railroad approval.

1.15 CONSTRUCTION OPERATIONS UNDER RAILROAD TRAFFIC

- A. General: Construction equipment is defined for the purpose of this article as all types of equipment, vehicles, and tools used in connection with construction work. The term workmen include every person or firm performing work in or adjacent to public streets.
- B. Construction Operations:
 - 1. No construction work involving occupancy or impact of tracks shall take place without prior approval of the VRE and the Host Railroad.
 - 2. Contractor shall comply with instructions provided by the Railroad flagman, VRE, the CM and/or the Inspector regarding safety rules and regulations near active tracks.
- C. Crossing Tracks / Traffic Lanes: When crossing open traffic lanes by construction equipment is necessary, such crossing shall be safeguarded with flagmen.
- D. Removal of Traffic Control Devices: All temporary signs, barricades, barrier curbs, drums, and cones used for safeguard traffic in connection with construction work shall be removed at the close of the work day, unless the state of the work is such that warning devices are still needed and are adapted for night closing. In such cases notify VRE reasonably in advance of the normal quitting time that he may review the status of the work and request additional safety measures as he deems necessary.
- E. Storage: Material storage shall be limited to designated staging areas.

1.16 WORK, STAGING AND STORAGE AREAS

- A. The Contract Drawings will show the work areas available to Contractor for storage of project materials and for parking of project construction equipment. These areas will be provided to the Contractor for the duration of construction without charge. CM and Contractor will make a joint site visit to document condition of staging area prior to occupancy. Take photos for the record.
- B. The Contractor at their own expense, if necessary, shall provide additional work and storage space as approved by VRE.
- C. If off-site storage of materials and equipment is required, Contractor will be responsible for the maintenance, security, safety, and operation of these facilities. This cost will be considered

- part of the Contractor's general conditions. Transportation of materials and equipment to the Work site is the responsibility of the Contractor.
- D. Erect and maintain a 6-foot high chain link fence topped with 3-strands of barbed wire around perimeter of staging area. Protect all stored equipment from the weather. VRE accepts no responsibility for items stored in this area.
 - E. Upon completion of Construction, remove all temporary staging area facilities and return the areas to their original condition.
 - F. Do not stockpile construction materials, spoils, debris or refuse in any area other than that specifically approved for such purpose by the CM.
 - G. Constrain stockpiled material in a manner to prevent its movement by wind or train slip stream or draft.

1.17 TERMINATION AND REMOVAL

- A. Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.
 - 1. Properly recondition and restore those portions of the site occupied by temporary facilities and controls to condition acceptable to CM, at least equal to condition at time of start of Work, unless otherwise authorized in writing by CM.
 - 2. Materials and facilities that constitute temporary facilities are the property of Contractor. VRE reserves right to take possession of Project identification signs.
 - 3. Remove temporary paving not intended for or acceptable for integration into permanent paving. Where area is intended for landscape development, remove soil and aggregate fill that do not comply with requirements for fill or subsoil. Remove materials contaminated with road oil, asphalt and other petrochemical compounds, and other substances that might impair growth of plant materials or lawns. Repair or replace roadway paving, curbs, and sidewalks at temporary entrances, as required by authorities having jurisdiction.
 - 4. At Substantial Completion, clean and renovate permanent facilities used during construction period. Comply with final cleaning requirements in Division 01 Section 01 77 00 "Project Closeout."

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01 73 00**Execution of Work****PART 1 - GENERAL****1.01 SUMMARY**

- A. Section includes general administrative and procedural requirements governing execution of the Work including, but not limited to, the following:
 - 1. Subcontracting
 - 2. Cooperation of Contractor
 - 3. Cooperation with Utility Companies
 - 4. Cooperation Among Contractors
 - 5. Cutting and Patching
 - 6. Existing Conditions
 - 7. Preparation
 - 8. Installation
 - 9. Construction Survey/Layout
 - 10. Historical and Scientific Specimens
 - 11. Correction of the Work
 - 12. Products Installed by VRE
 - 13. Salvage Materials and Owner Provided Materials
 - 14. Progress Cleaning
 - 15. Dust Control
 - 16. Starting and Testing
 - 17. Protection of installed construction
 - 18. Maintenance of Work
 - 19. Removal of Unacceptable and Unauthorized Work

1.02 RELATED SECTIONS

- A. General Conditions for Construction
- B. Section 01 26 00 – Change Order Procedures
- C. Section 01 31 00 – Project Management and Coordination
- D. Section 01 32 00 – Construction Progress Documentation

- E. Section 01 45 00 – Quality Assurance and Quality Control
- F. Section 01 50 00 – Temporary Facilities and Controls

1.03 SUBMITTALS

- A. Qualification Data: For licensed land surveyor
- B. Certificates: Submit certificate signed by licensed land surveyor or certifying that location and elevation of improvements comply with requirements.
- C. Certified Surveys: Submit two copies signed by licensed land surveyor.

1.04 QUALITY ASSURANCE

- A. Land Surveyor Qualifications: A professional land surveyor who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing land-surveying services of the kind indicated.
- B. Manufacturer's Installation Instructions: Obtain and maintain on-site manufacturer's written recommendations and instructions for installation of products and equipment.

1.05 SUBCONTRACTING

- A. All subcontractors are subject to approval by the CM and VRE prior to such subcontractors performing any Work on the project. A subcontractor list shall be submitted to the CM for approval per Section 01 31 00, "Project Management and Coordination."

1.06 COOPERATION OF CONTRACTOR

- A. The Contractor shall give the Work the constant attention necessary to facilitate quality and progress, and shall fully cooperate with the CM, the Inspector, and other contractors involved in the prosecution of the Work. If any portion of a project is located within the limits of a municipality, military installation, or other federally owned property, the Contractor shall cooperate with the appropriate officials and their agents in the prosecution of the Work to the same extent as with VRE.
- B. The Contractor shall have on the project at all times during prosecution of the Work a competent Superintendent who is capable of reading and understanding the plans and Specifications, experienced in the type of work being performed, and who shall receive instructions from VRE, the CM, or their authorized representatives. The Superintendent shall have full authority to execute the orders and directions of the CM without delay and supply promptly such materials, equipment, tools, labor, and incidentals as may be required.

1.07 COOPERATION WITH UTILITY COMPANIES

- A. The adjustment of utilities consists of the relocation, removal, replacement, rearrangement, reconstruction, improvement, protection, disconnection, connection, shifting, or altering of an existing utility in any manner.
- B. Existing utilities within VRE's knowledge at the design stage of the project will be indicated on the plans. Where possible, VRE will make arrangements for adjusting these utilities prior to project construction. The utility owner will adjust existing private and public utilities that require adjustment, unless the Contract requires the Contractor to perform such adjustment as

- a pay item. The new location of such utilities may not be shown on the plans. Some utilities may remain or be adjusted within the construction limits simultaneously with project construction operations.
- C. The Contractor shall coordinate project construction with planned utility adjustments and take all necessary precautions to prevent disturbance of the utilities. The Contractor shall report to the CM any failure on the part of the utility owner to cooperate or proceed with the planned utility adjustments.
 - D. The Contractor shall perform Contract utility work in a manner that will cause the least inconvenience to the utility owner and those being served by the utility owner.
 - E. The Contractor shall protect existing, adjusted, or new utilities that are shown on the plans, marked by Miss Utility, or otherwise known to the Contractor that are to remain within the right of way so as to prevent disturbance or damage resulting from construction operations. If during prosecution of the work the Contractor encounters an existing utility that requires adjustment, they shall not interfere with the utility but shall take the proper precautions to protect the utility and shall promptly notify the CM of the need for adjustment.
 - F. If the Contractor desires the temporary or permanent adjustment of utilities for their own benefit, they shall conduct all negotiations with the utility owners and pay all costs in connection with the adjustment.
 - G. The Contractor shall promptly notify the CM in writing if the Contractor encounters utilities that are not shown on the plans, marked by Miss Utility, or otherwise known to the Contractor before the site is disturbed further and before the affected work is performed. Upon receipt of the Contractor's written notification, the CM will acknowledge receipt and investigate the conditions. The CM will notify the Contractor whether or not an adjustment to the Contract is warranted. Adjustments will be made according to Sections 01 26 00, "Change Order Procedures," as applicable.
 - H. No adjustment that results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

1.08 COOPERATION AMONG CONTRACTORS

- A. VRE may at any time contract or approve concurrent Contracts for performance of other work on, near, or within the same geographical area of the work specified in an existing Contract. Contractors shall not impede or limit access to such work by others.
- B. When separate Contracts are awarded within the limits of one project, contractors shall not hinder the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other. In the case of dispute, all Contractors shall proceed as directed by the CM.
- C. When Contracts are awarded to separate Contractors for known concurrent construction in a common area, the Contractors, in conference with the CM, shall establish a written joint schedule of operations. The schedule shall be based on the limitations of the individual Contracts and the joining of the work of one Contract with the others. The schedule shall set forth the approximate dates and sequences for the several items of work to be performed and

- shall ensure completion within the respective Contract time limit. The schedule shall be submitted to the CM for review and approval no later than 30 days after the award date of the later Contract and prior to the first monthly application for payment. The schedule shall be agreeable to, signed by, and binding on each Contractor. The CM may allow modifications of the schedule when benefit to the Contractors and VRE will result.
- D. Any modification of the schedule shall be in writing, mutually agreed to and signed by the contractors, and shall be binding on the contractors in the same manner as the original agreement.
 - E. If the contractors fail to agree on a joint schedule of operations, they shall submit their individual schedules to the CM, who will prepare a schedule that will be binding on each Contractor.
 - F. The joint schedule and any modification thereof shall become a part of each Contract involved. The failure of any Contractor to abide by the terms of the joint schedule will be justification for declaring the Contractor in default of their Contract.
 - G. Each Contractor shall assume all liability, financial or otherwise, in connection with their Contract and shall protect and save harmless the Owner from any and all damages and claims that may arise because of any inconvenience, delay, or loss he experiences as a result of the presence and operations of other contractors working in or near the work covered by their Contract. They shall also assume all responsibility for any of their work not completed because of the presence or operation of other Contractors.
 - H. VRE will not assume any responsibility for acts, failures, or omissions of one Contractor that delay the work of another except as provided herein.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.01 CUTTING AND PATCHING

- A. Cutting: Removal of in-place construction necessary to permit installation of other work.
- B. Patching: Fitting and repair work required to restore construction to original conditions after installation of other work.
- C. The Contractor is responsible for cutting, fitting, or patching as required. The Contractor shall not unnecessarily damage any portion of the project work by cutting, fitting, or patching. Any damages resulting from cutting, fitting, or patching in the project shall be borne by the Contractor.
- D. Cutting and Patching Plan: Submit plan describing procedures at least 10 days prior to the time cutting and patching will be performed. Include the following information:
 - 1. Extent: Describe reason for and extent of each occurrence of cutting and patching.

2. Changes to In-Place Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building appearance and other significant visual elements.
3. Products: List products to be used for patching and firms or entities that will perform patching work.
4. Dates: Indicate when cutting and patching will be performed.
5. Utilities and Mechanical and Electrical Systems: List services and systems that cutting and patching procedures will disturb or affect. List services and systems that will be relocated and those that will be temporarily out of service. Indicate length of time permanent services and systems will be disrupted.
 - a. Include description of provisions for temporary services and systems during interruption of permanent services and systems.

3.02 EXISTING CONDITIONS

- A. The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities, mechanical and electrical systems, and other construction affecting the Work.
 1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; underground electrical services, and other utilities.
 2. Furnish location data for work related to Project that must be performed by public utilities serving Project site.
- B. Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Subcontractor, Installer, or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.
 1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
 2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
 3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
- C. Written Report: Where a written report listing conditions detrimental to performance of the Work is required by other Sections, include the following:
 1. Description of the Work.
 2. List of detrimental conditions, including substrates.
 3. List of unacceptable installation tolerances.

4. Recommended corrections.
- D. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions and the cost of any and all remedial work required due to installation on unacceptable surfaces and substrates or under improper conditions shall be borne by the Contractor.

3.03 PREPARATION

- A. Furnish information to local utility and/or Owner that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.
 1. Refer to Section 01 11 00, "Summary of Work," for utility information.
- B. Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
- C. Verify space requirements and dimensions of items shown diagrammatically on Drawings.
- D. Immediately upon discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to the CM according to requirements in Section 01 31 00, "Project Management and Coordination."

3.04 INSTALLATION

- A. Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.
 1. Make vertical work plumb and make horizontal work level.
 2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
 3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.
- B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.
- C. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.
- D. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.
- E. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.
- F. Do not use tools or equipment that produce harmful noise levels. Noise ordinances issued by the Authority Having Jurisdiction must be followed.

- G. Obtain and distribute to the parties involved templates for work specified to be factory prepared and field installed. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.
- H. Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned with other portions of the Work. Where size and type of attachments are not indicated, verify size and type required for load conditions.
 - 1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by VRE or the CM.
 - 2. Allow for building movement, including thermal expansion and contraction.
 - 3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
- I. Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.

3.05 CONSTRUCTION SURVEY/LAYOUT

- A. Unless otherwise specified, the Contractor shall establish all baselines for the location of the principal component parts of the Work, establish a suitable number of benchmarks adjacent to the Work, and develop all detailed surveys necessary for construction. The Contractor shall carefully preserve benchmarks, reference points and stakes, and in the case of destruction thereof by the Contractor or due to the Contractor's negligence or the negligence of any subcontractor, the Contractor shall be responsible for expense and damage resulting therefrom and shall be responsible for any mistakes that may be caused by the loss or disturbance of such benchmarks, reference points and stakes.
- B. Before proceeding to lay out the Work, the Contractor shall verify layout information shown on Drawings, in relation to the property survey and existing benchmarks. If discrepancies are discovered, promptly notify the CM.
- C. The Contractor shall engage a land surveyor licensed in the jurisdiction where the project is physically located to lay out the Work using accepted surveying practices. The licensed land surveyor shall:
 - 1. Establish benchmarks and control points to set lines and levels at each story of construction and elsewhere as needed to locate each element of the project
 - 2. Establish limits on use of project site
 - 3. Establish dimensions within tolerances indicated. Do not scale Drawings to obtain required dimensions.
 - 4. Inform installers of lines and levels to which they must comply
 - 5. Check the location, level, and plumb, of every major element as the Work progresses

6. Notify the CM when deviations from required lines and levels exceed allowable tolerances
 7. Close site surveys with an error of closure equal to or less than the standard established by the AHJ
 8. Locate and lay out site improvements, including grading, fill and topsoil placement, ramps and walkways, utility slopes, and rim and invert elevations.
 9. Locate and lay out control lines and levels for structures, station platforms, building foundations, column grids, and floor levels, including those required for mechanical and electrical work
 10. Transfer survey markings and elevations for use with control lines and levels
 11. Level foundations and piers from two or more locations
- D. Maintain a record log of layout control work. Record deviations from required lines and levels. Include beginning and ending dates and times of surveys, weather conditions, name and duty of each survey party member, and types of instruments and tapes used. Make the log available for reference by the CM upon request.
- E. Benchmarks
1. Refer to drawings for existing benchmarks, control points, and property corners
 2. Locate existing permanent benchmarks, control points, and similar reference points before beginning the Work. Preserve and protect permanent benchmarks and control points during construction operations.
 - a. Do not change or relocate existing benchmarks or control points without prior written approval of the CM. Report lost or destroyed permanent benchmarks or control points promptly. Report the need to relocate permanent benchmarks or control points to CM before proceeding.
 - b. Replace lost or destroyed permanent benchmarks and control points promptly. Base replacements on the original survey control points.
 3. Establish and maintain a minimum of two permanent benchmarks on Project site, referenced to data established by survey control points. Comply with authorities having jurisdiction for type and size of benchmark.
 4. Record benchmark locations, with horizontal and vertical data, on Project Record Documents.
 5. Where the actual location or elevation of layout points cannot be marked, provide temporary reference points sufficient to locate the Work.
 6. Remove temporary reference points when no longer needed. Restore marked construction to its original condition.

3.06 HISTORICAL AND SCIENTIFIC SPECIMENS

- A. All articles of historical/scientific value or archeological significance, including coins, fossils, and articles of antiquity, which may be uncovered by Contractor during progress of the work,

shall become the property of VRE. Such findings shall be reported immediately to the Construction Manager who will determine method of removal, where necessary, and final disposition thereof.

3.07 CORRECTION OF THE WORK

- A. Repair or remove and replace defective construction. Restore damaged substrates and finishes. Comply with requirements in this Specification Section.
 - 1. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment.
- B. Restore permanent facilities used during construction to their specified condition.
- C. Remove and replace damaged surfaces that are exposed to view if surfaces cannot be repaired without visible evidence of repair.
- D. Repair components that do not operate properly. Remove and replace operating components that cannot be repaired.
- E. Remove and replace chipped, scratched, and broken glass or reflective surfaces in kind.

3.08 PRODUCTS INSTALLED BY VRE

- A. Provide access to Project site for VRE's construction personnel.
- B. Coordinate construction and operations of the Work with work performed by VRE construction personnel.
 - 1. Inform VRE of Contractor's preferred construction schedule for VRE's portion of the Work. Adjust construction schedule based on a mutually agreeable timetable. Notify VRE if changes to schedule are required due to differences in actual construction progress.
 - 2. Include VRE's construction personnel at pre-activity meetings covering portions of the Work that are to receive VRE's work. Attend pre-activity meetings conducted by VRE's construction personnel if portions of the Work depend on VRE's construction.
- C. Contractor shall be responsible for maintaining all products installed by VRE. The Contractor shall take all necessary precautions for safety of and shall provide reasonable protection to prevent damage, injury or loss to persons, properties, equipment and vehicles.
 - 1. Damage to products installed by VRE, caused by the Contractor, shall be repaired or replaced to the satisfaction of VRE at the expense of the Contractor.
 - 2. VRE, at its sole discretion, shall have the right to repair and/or replace damaged products. Such costs shall be deducted from Contractor invoices upon completion of the repair or replacement of the damage.

3.09 SALVAGE MATERIALS AND OWNER PROVIDED MATERIALS

- A. The Contractor shall maintain adequate property control records for materials and equipment specified to be salvaged. Contractor shall be responsible for the adequate storage and protection of salvaged materials and equipment. The Contractor shall replace, at no cost to VRE salvage materials and equipment that are broken or damaged during the salvage operations as the result

of the Contractor's negligence. Salvage material not specified for reuse shall be the property of the Contractor and shall be removed from the site.

- B. Owner provided materials shall become the responsibility of the contractor upon mobilization to the site and shall be treated and secured typical to other material to be used on the project.

3.10 PROGRESS CLEANING

- A. Maintain and clean project site and work areas daily, including common areas. Coordinate progress cleaning for joint-use areas where more than one installer has worked. Enforce requirements strictly. Dispose of materials lawfully.
 - 1. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
 - 2. Do not hold waste materials more than seven calendar days during normal weather or three calendar days if the temperature is expected to rise above 80 deg F.
 - 3. Contain hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.
 - a. Use containers intended for holding waste materials of type to be stored.
 - 4. Coordinate progress cleaning for joint-use areas where Contractor and other contractors are working concurrently.
 - 5. Do not transport construction debris through occupied areas of existing facilities.
- B. Maintain project site free of waste materials and debris.
- C. Maintain and clean areas where work is in progress to the level of cleanliness necessary for proper execution of the Work.
 - 1. Remove liquid spills promptly.
 - 2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.
- D. Keep railroad tracks and adjacent spaces clear of mud, dirt, debris, and any other substances or construction materials at all times.
- E. Public roads, driveways, and pedestrian areas shall be cleared of all mud, dust, debris, etc. on a daily basis or as directed by the CM.
- F. Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.
- G. Remove debris from concealed spaces before enclosing the space.
- H. Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

- I. Do not bury or burn waste materials on site. Do not wash waste materials down sewers or into waterways. Comply with waste disposal requirements in Section 01 50 00, "Temporary Facilities and Controls."
- J. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.
- K. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.
- L. Supervise construction operations to assure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.
- M. Responsibilities of the Contractor:
 - 1. Dumpsters shall be located at each site, accessible to building and roads. Each Contractor may legally load acceptable construction debris into the dumpsters from this project only. Cost of all disposal fees shall be by the Contractor and dumpsters shall remain on the project until project completion, or as directed by the CM. The Contractor shall secure dumpsters during off-hours. This excludes asbestos items.
 - 2. The Contractor is responsible for clean-up and disposal of waste materials, debris and rubbish on a daily basis.
 - 3. The Owner may issue written notification of insufficient cleaning relative to the requirements of this Section. Upon issuance of the cleaning notice:
 - a. All waste and accumulation of trash containing the Contractor's debris shall be removed from the Owner's premises within 24 hours of notification.
 - b. All designated project areas containing the Contractor's debris or requiring general housekeeping shall be left fine broom clean (interior) or raked clean (exterior or rough surface). Sweeping compound shall be used for all interior broom cleaning to control dust.
 - c. Failure by the Contractor to comply with the 24-hour requirement of the notice to the satisfaction of the Owner will result in a cleaning program directed by the Owner at the expense of the Contractor. Cost of clean-up performed by the Owner will be deducted from the Contractor's Request for Payment.
 - 4. Maintain areas under Contractor's control free of waste materials, debris, and rubbish. Maintain site in a clean and orderly condition.
 - 5. Daily clean interior areas to provide suitable conditions for work.
 - 6. Broom clean interior areas prior to start of surface finishing and continue cleaning on an as-needed basis.

7. Control cleaning operations so that dust and other particles will not adhere to wet or newly coated surfaces.
8. Remove waste materials, debris, and rubbish from site or to a dumpster provided by the Contractor daily.
9. The Contractor shall provide end-of-day cleanup of all work on a daily basis, conforming to requirements above.

3.11 DUST CONTROL

- A. The Contractor shall, at all times, control the spread of dust and dirt during the execution of the work. Use water mist, temporary closures, and other suitable methods. Use wet saws for cutting. Provide walk-off mats at entrances and exits to construction areas.
 1. Do not use water when it may damage existing construction or create hazardous or objectionable conditions.
 2. Wet mop floors to eliminate trackable dust and dirt and wipe down walls and doors of dust and dirt.
- B. Do not direct dust and dirt onto railroad tracks during cleaning.

3.12 STARTUP AND TESTING

- A. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace with new units, and retest.
- B. Adjust equipment for proper operation. Adjust operating components for proper operation without binding.
- C. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Comply with manufacturer field service requirements as noted in Section 01 45 00, "Quality Assurance and Quality Control."

3.13 PROTECTION OF INSTALLED CONSTRUCTION

- A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.
- B. Comply with manufacturer's written instructions for temperature and relative humidity.
- C. Supervise construction operations to ensure that in progress work is not stored on and/or effects completed construction such as floors and walls, which are subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.
- D. Roof Areas:
 1. Construction traffic and storage of materials on completed roof surfaces is not allowed. Where work is required, the contractor shall submit a protection plan, 14 calendar days prior to scheduled commencement of the work. Protection plan to include the following:
 - a. Type of work to be performed.

- b. Location of work areas.
 - c. Route of materials and workers to work area.
 - d. Materials and methods to be used.
2. Proceed with work after owner's authorization. Damage to roof surfaces shall be repaired and the cost of any and all remedial work shall be borne by the Contractor.

3.14 MAINTENANCE OF WORK

- A. The Contractor shall maintain the Work, the project site, construction area, railway, roadway, and passenger areas affected by construction from the beginning of construction operations until final acceptance with adequate equipment and forces to keep the roadway and structures in a safe and satisfactory condition at all times and to ensure the continuous and effective day by day prosecution of the Work.
- B. The Contractor shall bear all costs of performing maintenance work before final completion.

3.15 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK

- A. Work that does not conform to the Contract requirements, whether the result of unacceptable workmanship, use of unacceptable materials, damage through carelessness, or any other cause within the Contractor's control, will be considered unacceptable work.
- B. Unacceptable work shall be remedied or removed as determined by the CM and replaced in an acceptable manner at the Contractor's expense. The CM may accept the unacceptable work at a reduced price when acceptance is considered to be in the best interest of the public.
- C. Work that is done contrary to the instructions of the CM, contrary to the requirements of the Contract, beyond the lines shown on the plans or as designated by the CM except as specified herein, or without authority will be considered unauthorized and will not be paid for. The CM may order the Contractor to remove or replace unauthorized work at the Contractor's expense.
- D. The Contractor shall not perform destructive sampling or testing of the work without written authorization of the CM. Unauthorized destructive sampling or testing will cause the work to be considered unacceptable.
- E. In the event the Contractor is granted authorization to perform destructive sampling or testing, the Contractor shall obtain the approval of the CM for the method and location of each test prior to beginning such sampling or testing. In addition, destructive sampling and testing shall be performed in the presence of the CM.

END OF SECTION

SECTION 01 74 19**CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for the following:
 - 1. Salvaging nonhazardous demolition and construction waste.
 - 2. Recycling nonhazardous demolition and construction waste.
 - 3. Disposing of nonhazardous demolition and construction waste.
- B. Related Requirements:
 - 1. Section 024119 "Selective Demolition".
 - 2. Section 042000 "Concrete Unit Masonry".
 - 3. Section 042100 "Clay Unit Masonry – Thin Brick".
 - 4. CSX Section 070220 "Demolish and Remove Existing Structure" in the Appendix for removal of railings that may have lead paint on them.
 - 5. Track Specification in the Appendix - "Standard Specification for Disposal of Creosote Treated Wood Railroad Ties and Other Creosote Treated-Wood Debris."
 - 6. Section 311000 "Site Clearing" for disposition of waste resulting from site clearing and removal of above- and below-grade improvements.

1.3 DEFINITIONS

- A. Construction Waste: Building, structure, and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.
- B. Demolition Waste: Building, structure, and site improvement materials resulting from demolition operations.
- C. Disposal: Removal of demolition or construction waste and subsequent salvage, sale, recycling, or deposit in landfill, incinerator acceptable to authorities having jurisdiction, or designated spoil areas on Owner's property.
- D. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.

- E. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.
- F. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.

1.4 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition and construction waste becomes property of Contractor.
- B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
 - 1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.5 ACTION SUBMITTALS

- A. Waste Management Plan: Submit plan within 30 days of date established for the Notice to Proceed.

1.6 INFORMATIONAL SUBMITTALS

- A. Waste Reduction Progress Reports: Concurrent with each Application for Payment, submit report. Include the following information:
 - 1. Material category.
 - 2. Generation point of waste.
 - 3. Total quantity of waste in tons (tonnes).
 - 4. Quantity of waste salvaged, both estimated and actual in tons (tonnes).
 - 5. Quantity of waste recycled, both estimated and actual in tons (tonnes).
 - 6. Total quantity of waste recovered (salvaged plus recycled) in tons (tonnes).
 - 7. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.
- B. Waste Reduction Calculations: Before request for Substantial Completion, submit calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.
- C. Records of Donations: Indicate receipt and acceptance of salvageable waste donated to individuals and organizations. Indicate whether organization is tax exempt.
- D. Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals and organizations. Indicate whether organization is tax exempt.
- E. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

- F. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
- G. Qualification Data: For waste management coordinator.

1.7 QUALITY ASSURANCE

- A. Waste Management Coordinator Qualifications: Experienced firm, or individual employed and assigned by General Contractor, with a record of successful waste management coordination of projects with similar requirements. Superintendent may serve as Waste Management Coordinator.
- B. Regulatory Requirements: Comply with transportation and disposal regulations of authorities having jurisdiction.
- C. Waste Management Conference(s): Conduct conference(s) at Project site to comply with requirements in Section 013100 "Project Meetings." Review methods and procedures related to waste management including, but not limited to, the following:
 - 1. Review and discuss waste management plan including responsibilities of each contractor and waste management coordinator.
 - 2. Review requirements for documenting quantities of each type of waste and its disposition.
 - 3. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
 - 4. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
 - 5. Review waste management requirements for each trade.

1.8 WASTE MANAGEMENT PLAN

- A. General: Develop a waste management plan according to requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. Distinguish between demolition and construction waste. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.
- B. Waste Identification: Indicate anticipated types and quantities of demolition, site-clearing and construction waste generated by the Work. Include estimated quantities and assumptions for estimates.
- C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.
 - 1. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work in compliance with Section 024119 "Selective Demolition."
 - 2. Salvaged Materials for Sale: For materials that will be sold to individuals and organizations, include list of their names, addresses, and telephone numbers.

3. Salvaged Materials for Donation: For materials that will be donated to individuals and organizations, include list of their names, addresses, and telephone numbers.
 4. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
 5. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
 6. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location where materials separation will be performed.
- D. Cost/Revenue Analysis: Indicate total cost of waste disposal as if there were no waste management plan and net additional cost or net savings resulting from implementing waste management plan. Include the following:
1. Total quantity of waste.
 2. Estimated cost of disposal (cost per unit). Include transportation and tipping fees and cost of collection containers and handling for each type of waste.
 3. Total cost of disposal (with no waste management).
 4. Revenue from salvaged materials.
 5. Revenue from recycled materials.
 6. Savings in transportation and tipping fees by donating materials.
 7. Savings in transportation and tipping fees that are avoided.
 8. Handling and transportation costs. Include cost of collection containers for each type of waste.
 9. Net additional cost or net savings from waste management plan.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General: Achieve end-of-Project rates for salvage/recycling of 75 percent by weight of total nonhazardous solid waste generated by the Work. Practice efficient waste management in the use of materials in the course of the Work. Use all reasonable means to divert construction and demolition waste from landfills and incinerators. Facilitate recycling and salvage of materials, including the following:
1. Demolition Waste:
 - a. Asphalt paving.
 - b. Concrete.
 - c. Concrete reinforcing steel.
 - d. Electrical conduit.
 - e. Lighting fixtures.
 - f. Lamps.
 - g. Ballasts.
 2. Construction Waste:

- a. Masonry and CMU.
- b. Lumber.
- c. Wood sheet materials.
- d. Metals.
- e. Roofing.
- f. Insulation.
- g. Gypsum board.
- h. Piping.
- i. Electrical conduit.
- j. Packaging: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following uncontaminated packaging materials:
 - 1) Paper.
 - 2) Cardboard.
 - 3) Boxes.
 - 4) Plastic sheet and film.
 - 5) Polystyrene packaging.
 - 6) Wood crates.
 - 7) Wood pallets.
 - 8) Plastic pails.
- k. Construction Office Waste: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following construction office waste materials:
 - 1) Paper.
 - 2) Aluminum cans.
 - 3) Glass containers.

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

- A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.
 - 1. Comply with operation, termination, and removal requirements in Section 015000 "Temporary Facilities and Controls."
- B. Waste Management Coordinator: Engage a waste management coordinator to be responsible for implementing, monitoring, and reporting status of waste management work plan.
- C. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work.
 - 1. Distribute waste management plan to everyone concerned within three days of submittal return.

2. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.
- D. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged and recycled.
 2. Comply with Section 015000 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

3.2 SALVAGING DEMOLITION WASTE

- A. Comply with requirements in Section 024119 "Selective Demolition" for salvaging demolition waste.
- B. Salvaged Items for Reuse in the Work: Salvage items for reuse and handle as follows:
1. Clean salvaged items.
 2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
 3. Store items in a secure area until installation.
 4. Protect items from damage during transport and storage.
 5. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.
- C. Salvaged Items for Sale and Donation: Not permitted on Project site.
- D. Salvaged Items for Owner's Use: Salvage items for Owner's use and handle as follows:
1. Clean salvaged items.
 2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
 3. Store items in a secure area until delivery to Owner.
 4. Transport items to Owner's storage area designated by Owner.
 5. Protect items from damage during transport and storage.
- E. Equipment: Drain tanks, piping, and fixtures. Seal openings with caps or plugs. Protect equipment from exposure to weather.
- F. Plumbing Fixtures: Separate by type and size.
- G. Lighting Fixtures: Separate lamps by type and protect from breakage.
- H. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.

3.3 RECYCLING DEMOLITION AND CONSTRUCTION WASTE, GENERAL

- A. General: Recycle paper and beverage containers used by on-site workers.
- B. Recycling Incentives: Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall accrue to Owner.
- C. Preparation of Waste: Prepare and maintain recyclable waste materials according to recycling or reuse facility requirements. Maintain materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.
- D. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical according to approved construction waste management plan.
 - 1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.
 - a. Inspect containers and bins for contamination and remove contaminated materials if found.
 - 2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
 - 4. Store components off the ground and protect from the weather.
 - 5. Remove recyclable waste from Owner's property and transport to recycling receiver or processor as often as required to prevent overfilling bins.

3.4 RECYCLING DEMOLITION WASTE

- A. Asphalt Paving: Grind asphalt to maximum 1-1/2-inch (38-mm) size.
 - 1. Crush asphaltic concrete paving and screen to comply with requirements in Section 312000 "Earth Moving" for use as general fill.
- B. Asphalt Paving: Break up and transport paving to asphalt-recycling facility.
- C. Concrete: Remove reinforcement and other metals from concrete and sort with other metals.
 - 1. Pulverize concrete to maximum 1-1/2-inch (38-mm) size.
 - 2. Crush concrete and screen to comply with requirements in Section 312000 "Earth Moving" for use as satisfactory soil for fill or subbase.
- D. Masonry: Remove metal reinforcement, anchors, and ties from masonry and sort with other metals.
 - 1. Pulverize masonry to maximum 1-inch (25-mm) size.

- a. Crush masonry and screen to comply with requirements in Section 312000 "Earth Moving" for use as general fill.
- 2. Clean and stack undamaged, whole masonry units on wood pallets.
- E. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.
- F. Metals: Separate metals by type.
 - 1. Structural Steel: Stack members according to size, type of member, and length.
 - 2. Remove and dispose of bolts, nuts, washers, and other rough hardware.
- G. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.
- H. Piping: Reduce piping to straight lengths and store by material and size. Separate supports, hangers, valves, sprinklers, and other components by material and size.
- I. Conduit: Reduce conduit to straight lengths and store by material and size.
- J. Lamps: Separate lamps by type and store according to requirements in 40 CFR 273.

3.5 RECYCLING CONSTRUCTION WASTE

- A. Packaging:
 - 1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
 - 2. Polystyrene Packaging: Separate and bag materials.
 - 3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
 - 4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.
- B. Wood Materials:
 - 1. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
 - 2. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.
- C. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location.
 - 1. Clean Gypsum Board: Grind scraps of clean gypsum board using small mobile chipper or hammer mill. Screen out paper after grinding.
- D. Paint: Seal containers and store by type.

3.6 DISPOSAL OF WASTE

- A. General: Except for items or materials to be salvaged or recycled, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.
 - 1. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B. General: Except for items or materials to be salvaged or recycled, remove waste materials and legally dispose of at designated spoil areas on Owner's property.
- C. Burning: Burning of waste materials is prohibited.

3.7 ATTACHMENTS

- A. Form CWM-1 for construction waste identification.
- B. Form CWM-2 for demolition waste identification.
- C. Form CWM-3 for construction waste reduction work plan.
- D. Form CWM-4 for demolition waste reduction work plan.
- E. Form CWM-5 for cost/revenue analysis of construction waste reduction work plan.
- F. Form CWM-6 for cost/revenue analysis of demolition waste reduction work plan.
- G. Form CWM-7 for construction waste reduction progress report.
- H. Form CWM-8 for demolition waste reduction progress report.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 017419

SECTION 01 77 00**Closeout Procedures****PART 1 - GENERAL****1.01 SUMMARY**

- A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:
 - 1. Closeout Submittals
 - 2. Substantial Completion Procedures
 - 3. Project Punchlist
 - 4. Final Completion Procedures
 - 5. Operation and Maintenance Manuals
 - 6. Warranties and Guarantees
 - 7. Project Record Documents
 - 8. Final Cleaning
 - 9. Repair of the Work

1.02 RELATED SECTIONS

- A. Section 01 29 00 – Payment Procedures
- B. Section 01 32 00 – Construction Progress Documentation
- C. Section 01 45 00 – Quality Assurance and Quality Control
- D. Section 01 73 00 – Execution of Work

1.03 SUBMITTALS

- A. Closeout submittals shall include, but not be limited to, the following:
 - 1. Certificate or Letter of Substantial Completion (provided to Contractor by CM)
 - 2. Certificate of Occupancy (or Certificate of Final Inspection) from the AHJ
 - 3. Project Record Documents
 - a. As-Built / Red Line Contract Drawings
 - b. As-Built / Red Line Shop Drawings
 - c. As-Built / Red Line Specifications
 - d. As-Built Construction Schedule
 - 4. Operation and Maintenance Manual(s)
 - 5. Warranties

6. Maintenance Bond (if applicable)
7. Final Certified Payroll Records
8. Spare Parts / Stock Materials (as required per Technical Specifications)
9. Post-Construction Photos
10. Affidavit of Payment of Debts and Claims (Contractor and Subcontractors)
11. Releases of Liens (Contractor and Subcontractors)
12. Consent of Surety to Final Payment
13. Final DBE Utilization Statement (if applicable)
14. Final Application for Payment
15. Contractor Closeout Checklist, signed

1.04 SUBSTANTIAL COMPLETION PROCEDURES

A. Definition

1. "Substantial Completion" is the condition when VRE agrees that the Work, or a specific portion thereof, is sufficiently complete, in accordance with the Contract Documents, so that it can be utilized by VRE for the full use and function for which it was intended, including the issuance of a Certificate of Occupancy, if applicable, and/or Host Railroad acceptance, if applicable. The date of Substantial Completion of the Work under the Contract is the milestone date on which Substantial Completion condition is accomplished. The only remaining physical work shall be the completion of punch list work prior to Final Acceptance.

B. Substantial Completion Inspection

1. No less than fourteen (14) calendar days prior to the date the Contractor plans to have the Work, or designated portions of the Work, Substantially Complete, the Contractor shall provide a written notice to VRE, requesting VRE review/inspect the Project for Substantial Completion. Attached to this request should be a list of items the Contractor has not yet completed.
2. Before requesting inspection for determining date of Substantial Completion, complete the following. List items below that are incomplete in request.
 - a. Prepare list of items to be completed and corrected, indicating the value of each item on the list, the reasons why the Work is incomplete and a schedule for completing the work.
 - b. Ensure previously outstanding technical submittals and Shop Drawings have been submitted and approved.
 - c. Advise CM of pending insurance changeover requirements.

- d. Obtain and submit releases permitting VRE unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
- e. Prepare and submit Project Record Documents except Record Contract CPM Schedule; also prepare and submit Operation and Maintenance manuals, Substantial Completion construction photographs and damage or settlement surveys.
- f. Prepare and submit proof that specified testing and code inspections have been completed, accepted and certified, including, but not limited to, structural work, sprinkler piping systems, fire alarm and FPS systems, electrical system testing, and hydrostatic pressure testing of sanitary lines. Submit all regulatory and Host Rail Agency approvals as applicable.
- g. Deliver tools, spare parts, extra materials, and similar items to location designated by CM. Label with manufacturer's name and model number where applicable.
- h. Complete startup testing of systems.
- i. Submit test/adjust/balance records.
- j. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
- k. Advise VRE of changeover in utilities.
- l. Submit changeover information related to VRE's occupancy, use, operation, and maintenance.
- m. Instruct VRE's personnel in operation, adjustment, and maintenance of products, equipment, and systems, as required by Contract Documents. Submit demonstration and training videos.
 - i. Assemble educational materials necessary for instruction, including documentation and training.
 - ii. Provide instruction at mutually agreed on times.
 - 1. Schedule training with CM with at least 15 calendar days' advance notice.
 - 2. Submit training agenda to CM for review and approval for each system/equipment no later than 15 calendar days prior to the scheduled system/equipment startup. After approving the agenda, CM shall provide a listing of dates, times and places of the training programs for Contractor coordination.
 - iii. VRE shall provide space with tables and chairs, if applicable, for conducting the classroom portion of all training.
 - iv. Provide instructional equipment at instruction location.
- n. Complete final cleaning requirements.

- o. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.
 - 3. Inspection: Upon receipt of the notice, VRE or designee shall schedule an inspection of the Project in the form of a complete walkthrough with the Contractor's Project Manager, Superintendent or designated representative, to inspect the work and notify the Contractor of any deficiencies. When it has been determined the work is substantially complete, VRE will prepare a certificate of substantial completion listing minor deficiencies, if any, to be corrected.
 - a. Re-inspection: Request re-inspection when the Work identified in previous inspections as incomplete is completed or corrected.
 - b. Punch list work must be completed before final completion. Failure to complete the punch list work within 60 calendar days of issuance, may result in VRE ordering the work to be completed by others at the cost to Contractor and deducting the value of such from retainage withheld.
 - c. Results of completed inspection will form the basis of requirements for Final Acceptance.
- C. Certificate of Substantial Completion

When it has been determined by VRE that Substantial Completion has been attained, VRE will prepare a Certificate of Substantial Completion and formally transmit it to the Contractor.

1.05 PROJECT PUNCH LIST (INCOMPLETE ITEMS)

- 1. Following the Substantial Completion inspection, the Construction Manager will prepare and distribute a Project Punch List to the Contractor, VRE, and other parties as necessary.
- 2. The Project Punch List will be in tabular format and include the following information:
 - a. Sequential punch list item number
 - b. Description of the item requiring correction
 - c. Specific location on the Project of each item
 - d. Name of contractor, subcontractor, or other party responsible for the correction
 - e. Date item was originally recorded on the punch list
 - f. Blank columns for date and person's initials to be used for acceptance of each item
 - g. Name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.
- 3. Include the following information at the top of each page:
 - a. Contract name and number
 - b. Date

- c. Name of CM
 - d. Name of Contractor
 - e. Page number
4. Only the VRE Project Manager, the Construction Manager, or the Inspector can provide acceptance of punch list items.
 5. Final demobilization from the worksite is prohibited until punch list work is completed and accepted. Payment for demobilization will not be processed until punch list work is completed and accepted by VRE.

1.06 FINAL COMPLETION PROCEDURES

A. Definition

"Final Completion" is the condition when VRE agrees that all the Work has been fully completed in accordance with the Contract Documents, all punch list items have been addressed and accepted, final cleaning has been accomplished, all closeout submittals have been received in acceptable condition, demonstration and training of systems has taken place, the VRE Closeout Checklist has been completed, and the final Application for Payment from the Contractor has been reviewed and deemed acceptable by VRE. The date of Final Acceptance is the date of execution by the Contracting Officer of a Certificate of Final Acceptance.

B. When the Contractor believes the Project has reached Final Completion, as defined above, the Contractor shall provide a written notice to VRE, requesting VRE review the Project for Final Completion and release of retainage. The written notice shall indicate the following:

1. Contract documents have been reviewed and work has been inspected and found to be in compliance;
2. Deficiencies listed in the certificate of substantial completion have been corrected;
3. Equipment and systems have been tested, adjusted and balanced and are fully operational;
4. Operations of systems have been demonstrated to VRE and Host Rail Road;
5. Work is complete and is ready for final inspection and acceptance by VRE.

C. Before requesting VRE review the Project for Final Completion, all closeout submittals as described in this Specification section and requirements detailed in other individual Specification Sections, shall be submitted and accepted by VRE.

1. The Contractor's final Application for Payment shall be attached to the request for Final Completion.
 - a. Submit the final Application for Payment according to Section 01 29 00, "Payment Procedures."

2. Submit certified copy of CM's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by CM. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
3. Submit a Contractor/CM joint statement evidencing that all Record Documents such as stamped shop drawings (working drawings) red-line drawings, Operation and Maintenance Manuals, warranties, product data, survey records and similar required submittals have been approved.
 - a. Submit warranties required by Contract Documents, maintenance service agreements, final certifications, and similar documents.
 - i. Submit Contractor Warranty Letter, for review and approval, a minimum of 30 days before requesting inspection for Final Completion. The initiation date for all warranties and guarantees shall be the date of Final Completion.
4. Complete demobilization and removal of temporary facilities from the site including construction equipment and facilities, mockups, and other similar elements. Restore areas to previously existing condition, if applicable.
5. Execute final Contract Modification and submit final Subcontractor Payment Form
6. Evidence of compliance with requirements of governing agencies, if applicable, to include but not limited to:
 - a. Certificates of inspection
 - b. Certificate of occupancy
7. Evidence that claims have been settled.
8. Evidence of payment and release of liens such as but not limited to:
 - a. Contractor's affidavit of payment of debts and claims
 - b. Contractor's Affidavit of Release of Liens
 - c. Subcontractor's Affidavit of Release of Liens
 - d. Consent of Surety to Final Payment
9. Final adjustment of accounts
10. Final, liquidated damages settlement statement, if applicable.
11. Submit Record Contract CPM Schedule.
12. Return of all VRE issued property.
13. Spare Parts.
14. Labor certification.
15. Commissioning of new systems, as required
16. Training and demonstration of new systems, as required

17. Complete final cleaning requirements
 18. Submit pest-control final inspection report and warranty, if applicable.
 19. Turn over all salvaged materials to VRE as indicated on the plans and specifications.
- D. Release of Liens: VRE, before making any payment including Final Payment, shall require the Contractor to furnish a complete release of all liens arising out of this Contract, or receipts in full in lieu thereof, and if required in either case, an affidavit that so far as the Contractor has knowledge or information, the releases and receipts include all the labor and material for which a lien could be filed.
- E. Inspection: On receipt of request, CM will either proceed with inspection or notify Contractor of unfulfilled requirements. CM will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.
1. Re-inspection: Request re-inspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.07 OPERATION AND MAINTENANCE MANUALS, GENERAL

- A. Organization: Unless otherwise indicated, organize information by Division and then into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following in the order listed:
1. Title Page
 2. Table of Contents
 3. Manual Contents
- B. Title Page: Enclose title page in transparent plastic sleeve. Include the following information on the title page:
1. Specific subject matter included in manual such as Division number and title, Specification Section number and title, equipment, systems and subsystems.
 2. Name and number of the Contract.
 3. Date of submittal.
 4. Name, address, telephone number, and contact person of Contractor, Subcontractor, and supplier.
 5. Cross-reference to related systems in other portions of the Operation and Maintenance Manuals.
- C. Table of Contents: Include a printed, printed by a laser printer, table of contents for each volume, arranged according to the specification format. List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in the Contract Documents.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.
- D. Manual Contents: Organize into sets of manageable size. Arrange contents by Division then by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
 1. In addition to requirements in the sections below, include operation data required in individual Specification Sections.
 2. Include copies of Warranties or Guarantees for specific products or equipment in the applicable section of the O&M Manual.
 3. Binders: Heavy-duty, 3-ring vinyl covered loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents. Binders shall not be filled beyond 75 percent of their rated capacity.
 - a. Provide maximum 3-inch binder thickness. Smaller binders are acceptable as long as 75 percent rated binder capacity is not exceeded.
 - b. If two or more binders are necessary to accommodate data for a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
 - c. Identify each binder on front (If Identification cannot be placed on the front provide as the first page) and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Contract number and name, and specific subject matter of contents, such as "Division 06," to include Specification Section. Indicate volume number for multiple-volume sets. The use of business labels is prohibited.
 4. Dividers: Provide three-hole, heavyweight, and plastic tabbed dividers, for each separate Specification section number and title. Provide laser printed description for each tab section (front and back of tabs), to indicate the appropriate Specification Section. Provide a description of the product or heading for sub tabs using the same laser printed format on the dividers.
 5. Protective Plastic Sleeves: Provide protective transparent plastic sheet protectors to enclose the Title Page, all Table of Content pages, and photographs (if applicable).
 - a. For CD-ROMs, provide transparent plastic three-ring sleeves designed to accommodate CD-ROMs.
 6. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
 - a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.

- b. If drawings are too large to be used as foldouts, fold and place drawings in transparent envelopes and bind envelopes with text. Insert typewritten pages indicating drawing titles, descriptions of contents, in the transparent envelopes along with drawings. Drawings shall cross-reference the appropriate manual volume and Specification Section. Drawing holding envelopes are not acceptable.
- c. Provide operations and maintenance material on electronic version (CD-ROM or USB Drive).

1.08 OPERATION AND MAINTENANCE MANUALS

- A. Operation and Maintenance Manuals Initial Submittal: Submit one draft copies of each Manual in the approved format at least 30 calendar days before requesting inspection for Final Completion or any required training. Include a complete Operations and Maintenance Directory. CM will return a copy of draft within 30 calendar days of receipt, and mark whether general scope and content of Manuals are acceptable.
- B. Operation and Maintenance Manuals Revised Submittals: Submit one revised copies of each manual in final form, including one CD containing electronic O & M documentation, at least 10 calendar days before final completion or training, whichever occurs first. CM will return a copy with comments within 15 calendar days after receipt.
- C. At least 30 calendar days before Final or required training Completion, prepare and deliver to VRE one (1) electronic (.pdf) version (CD-ROM or USB) and three (3) hard copies of a manual containing all information pertaining to the operation and maintenance (O&M) of all products and equipment provided under the Contract.
 - 1. For purposes of payment, O & M and Material and Finishes Manuals will be submitted and accepted by VRE prior to final payment.
- D. Where operation and maintenance documentation includes information on installations by more than one factory-authorized service representative, the Contractor shall assemble and coordinate information furnished by representatives and prepare manuals.
- E. Operations and Maintenance Manual (Electronic Version)
 - 1. The O&M Manual shall consist of high-quality electronic files (or color prints of such files), legible, and not scanned from a hard copy. Include a table of contents and a cover sheet noting the project name, location, VRE contract number, and Substantial Completion date. Each document in the O&M Manual shall be preceded by an intermediate cover sheet containing the Specification section number and title, the name of the product or equipment, and the location at the Project where the product or equipment can be found.
 - 2. The electronic version of the O&M Manual shall contain "bookmarks" labeled with Specification section number and title, as well as sub-bookmarks within each Specification section noting the name of the product or equipment so that the document can be easily navigated by the user.
 - 3. Information in the electronic version shall be identical to information included in the Operations and Maintenance Manual (Hard Copy).

F. Operations and Maintenance Manual (Hard Copy)

1. Operations Content: Include requirements in this Section and other operation data and requirements detailed in individual Specification Sections. In addition, information will include, but not be limited to, the following information, if applicable. Organize manuals into separate and distinct volumes by Division.
 - a. System, subsystem and equipment descriptions
 - b. Safety instruction and related issues.
 - c. Performance and design criteria if Contractor is delegated design responsibility.
 - d. Operating standards.
 - e. Operating procedures.
 - f. Operating logs.
 - g. Wiring diagrams, including color-coding and terminal designations. Include all factory preset or field-set dip switch and jumper settings for all electronic equipment.
 - h. Control diagrams.
 - i. Piped system diagrams.
 - j. Precautions against improper use.
 - k. License requirements including inspection and renewal dates.
 - l. Material Safety Data Sheets.
2. Operating Procedures shall include but not be limited, to the following, as applicable.
 - a. Startup procedures
 - b. Equipment or system break-in procedures.
 - c. Routine and normal operating instructions.
 - d. Regulation and control procedures.
 - e. Instructions on stopping.
 - f. Normal shutdown instructions.
 - g. Seasonal and weekend operating instructions.
 - h. Required sequences for electric or electronic systems.
 - i. Special operating instructions and procedures.
 - j. Procedures or operations that may void warranty.
3. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

4. Piped Systems: Diagram piping as installed and color-coding shall be used where required for identification.
5. Maintenance Content: Organize information into a separate section for each product, material, and finish. Include requirements in this Section and other maintenance data and requirements detailed in individual Specification Sections. Provide one section for architectural products, including applied materials and finishes, and a second for products designed for moisture protection and products exposed to the weather.

Include source information, product information, maintenance procedures, repair materials and sources, schedule of products, location of products and warranties, as described below.

List each product included in manual identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

- a. Product Information shall include but not be limited, to the following, as applicable:
 - i. Product name and model number.
 - ii. Manufacturer's name.
 - iii. Color, pattern, and texture.
 - iv. Material and chemical composition.
 - v. Reordering information for specially manufactured products.
 - vi. Fire/flame-spread test certificates.
 - vii. Material Safety Data Sheets.
- b. Maintenance Procedures shall include but not be limited to, manufacturer's written recommendations and the following, as applicable:
 - i. Inspection procedures.
 - ii. Types of cleaning agents to be used and methods of cleaning.
 - iii. List of cleaning agents and methods of cleaning detrimental to product.
 - iv. Schedule for routine cleaning and maintenance.
 - v. Repair instructions.
 - vi. Preventative/predictive maintenance tasks and frequencies.
- c. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.
- d. Schedule of Products and Locations: Provide complete information, including reference drawings, in the materials and finishes manual on all products specified in all applicable Divisions.

- e. Warranties: Reference all applicable warranties listed in Warranty Manual. Include lists of circumstances and conditions that would affect validity of warranties or bonds.
 - i. Include procedures to follow and required notifications for warranty claims.
 - ii. Clearly indicate commencement and expiration dates.

1.09 WARRANTIES AND GUARANTEES

- A. Within 30 calendar days before requesting Final Completion or any required training, prepare and deliver to VRE one (1) electronic (.pdf) version and one (1) hard copy of all warranties and guarantees, made out to VRE, required by the Special Terms and Conditions, individual Specification sections, and other Contract Documents. Both versions shall be provided in color. Products and Equipment shall not be considered delivered (for payment purposes) until the approved warranties have been received,
- B. The initiation date for all warranties and guarantees shall be the date of Final Completion.
- C. Warranty Book/Manual: Organize warranty documents into an orderly sequence based on the table of the Contract Specifications. Warranty documents include Contractor and major subcontractors warranty letters, special warranty documents, and manufacturer's warranties.
 - 1. Include a table of contents and a cover sheet noting the project name, location, VRE contract number, and Substantial Completion date.
 - 2. The General Contractor's workmanship warranty shall be included as the first document in the warranty book.
 - 3. Include copies of warranties or guarantees for specific products or equipment in the applicable section of the O&M Manual.
 - 4. The hard copy of the warranty book shall be a heavy-duty 3-ring vinyl-covered binder containing tabbed dividers labeled with Specification section number and title.
 - i. Identify each binder on front and spine, with printed title "PROJECT WARRANTIES," Contract number and name and subject matter of contents. If identification cannot be attached to the front include it as the first page in the manual. Indicate volume number for multiple-volume sets.
 - ii. Dividers: Provide three-hole, heavyweight, plastic tabbed dividers, (or as approved by VRE) for each separate section. Provide laser printed description for each tabbed section on the front and back of tabs. Tabs shall indicate the appropriate Specification Section number and title. Provide a description of the warranty or heading for sub tabs using the same laser printed format on the dividers. Provide an index of the contents in each section on the first page behind each section divider.
- D. Electronic Version of Warranty Book/Manual: The electronic file containing warranties and guarantees shall contain "bookmarks" labeled with Specification section number and title, as well as sub-bookmarks within each Specification section noting the name of the product or

equipment so that the document can be easily navigated by the user. Information in the electronic version shall be identical to information included in the Warranty Book/Manual.

1.10 PROJECT RECORD DOCUMENTS

- A. Project Record Documents shall be the responsibility of the Contractor and shall consist of the following items:
 - 1. As-Built Contract Drawings
 - 2. As-Built Shop Drawings
 - 3. As-Built Specifications
 - 4. As-Built Construction Schedule
- B. Within 30 calendar days before requesting Final Completion or any required training, the Contractor shall submit one (1) electronic (.pdf) version and one (1) hard copy version of the Project Record Documents, to VRE for review and approval. It is acceptable to provide an annotated electronic (.pdf) document or scan the hard copy version in order to create the electronic file, provided all notes and sketches are legible. Both the electronic and hard copy versions must be provided in color. Hard copies of drawings shall be provided in 22" x 34" size.
- C. Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and modifications to Project Record Documents as they occur.
- D. Store Project Record Documents in the field office apart from the Contract Documents. Do not use project record documents for construction purposes. Maintain record documents in good order and in a clean, dry, legible condition protected from deterioration and loss. Repair or reproduce torn or dirty sheets. Provide access to Project Record Documents for CM 's reference during normal working hours.
- E. As-Built Contract Drawings
 - 1. The Contractor shall mark up one set of prints of the applicable Contract Drawings to portray as-built construction. The prints shall be neatly and clearly marked in red ink or red pencil to show all variations between the Work actually provided and that indicated on the Contract Drawings. All drafting shall conform to good drafting practice and shall include such supplementary notes, legends, and details as may be necessary for legibility and clear portrayal of the as-built construction.
 - 2. As-built drawings shall be maintained throughout the Project, incorporating new and revised drawings as modifications are issued, and finalized promptly at the completion of the Project. Routinely mark drawings to show the actual installation where installation varies from that shown originally. Record information in an understandable drawing technique. Ensure mark-ups are legible and reproducible. Record data as soon as possible after obtaining it. Record and check markups before enclosing concealed installations.

3. As-built drawings shall be kept current and available for inspection by the CM in a location accessible to the CM on a daily basis during working hours. The CM will review updates to the as-built drawings periodically to ensure they are maintained.
4. Information shown on the as-built drawings should include, but not be limited to:
 - a. Dimensional changes to Drawings
 - b. Revisions to details shown on Drawings
 - c. Depths of foundations below first floor
 - d. Locations and depths of underground utilities
 - e. Revisions to routing of piping and conduits
 - f. Revisions to electrical circuitry
 - g. Actual equipment locations
 - h. Duct size and routing
 - i. Locations of concealed internal utilities
 - j. Changes made by Change Order or Change Directive
 - k. Changes made following VRE's written orders
 - l. Details not on the original Contract Drawings
 - m. Field records for variable and concealed conditions
 - n. Actual installed information about Work that is otherwise shown only schematically
 - o. Other information about concealed elements that would be difficult to identify, measure or record later
 - p. Note Change Order numbers, RFI numbers, and similar identification, where applicable.
5. Format
 - a. Identify and date each record Drawing. Include the designation "PROJECT RECORD DRAWING" in a prominent location.
 - b. Cover Sheet shall have the designation "PROJECT RECORD DRAWINGS", Date, Name of Contractor, and signature.
6. Additional Requirements
 - a. When there are multiple copies of the same sheet with different mark-ups on each copy, the General Contractor is responsible for consolidating all mark-ups onto a single copy of each individual sheet.
 - b. The information from all RFI's, Change Notices, Design Clarifications, field adjustments, or any other changes, must be noted on the appropriate drawing. These mark-ups must include enough information to clearly show the actual constructed

conditions resulting from the change. The information may be drawn onto the drawing, copied onto the drawing or copied onto a new full-size sheet. Every change in construction must have RFI's, Change Orders or similar supplementary documents; therefore, they must be copied in original size and attached to the back of the preceding drawing or at the end of the drawing set, as an appendix, as a full-size sheet, same in size as the drawing set. Multiple RFI's, CN's and other supplemental documents may be copied in each single sheet.

- c. All changes made on the drawings shall reference the appropriate RFI, Change Notices, Design Clarification, or details from the contractor prepared shop drawings. If the mark-up is due to a field adjustment, it shall be indicated as such.
- d. Notes and sketches printed by hand are acceptable but shall be neat, legible, and reproducible.

F. As-Built Shop Drawings

As-built shop drawings shall be prepared in the same manner as the as-built contract drawings. A set of as-built shop drawings shall be provided for every set of shop drawings submitted and approved for use on the Project. Include electrical, mechanical, plumbing, structural steel, and other shop drawings as applicable to the Project.

- 1. Initial Submittal: Submit one set of complete, full-sized, As-Built Shop Drawings. Additional sets of drawings are not to be copied and submitted until after substantial completion to insure all changes are shown on the drawings. The CM will facilitate review of drawings and indicate whether the As-Built Shop Drawings are acceptable. The CM will return review comments indicating any corrections that need to be made to the drawings. The corrected As-Built Shop Drawings may then be reproduced, and organized into sets, printed, bound, and submitted as final submittal.
- 2. Final Submittal: After construction is complete and changes are recorded, submit three complete, full-sized, printed sets of As-Built Shop Drawings. Include each sheet, whether or not changes and additional information were recorded. Submit four copies of the As-Built Shop Drawings in the approved electronic format. In addition, submit the original set of marked-up record drawings onto which the mark-ups were made.

G. As-Built Specifications

The Contractor shall mark up one set of Specifications to show all variations between the Work actually provided and that indicated on the Contract Drawings. Include the following items on the as-built specifications.

- 1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
- 2. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.
- 3. Record the name of manufacturer, supplier, installer, and other information necessary to provide a record of selections made.

4. Note related Change Orders, Record Drawings, and Product Data where applicable.
- H. As-Built Construction Schedule
See Section 01 32 00, "Construction Progress Documentation," for details regarding the As-Built Construction Schedule.
- I. If Project Record Documents are not submitted in accordance with this Specification section, and other Contract requirements, as applicable, the submittal will not be reviewed and will be returned to the Contractor for revision and resubmittal.

PART 2 - PRODUCTS

- A. Cleaning Agents: For final cleaning, use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.
- B. Products - The Contractor shall turn over all salvaged materials to VRE, as necessary.

PART 3 - EXECUTION

3.01 FINAL CLEANING

- A. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations. Final cleaning shall include removal of all waste and surplus materials and equipment caused by the work prior to final inspection. Progress cleaning during construction is included in Division 01 Section "Execution of Work."
- B. Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
- C. The following cleaning operations shall be completed before requesting VRE review the Project for Substantial Completion:
 1. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
 2. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
 3. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
 4. Remove tools, construction equipment, machinery, and surplus material from Project site.
 5. Remove snow and ice to provide safe access to public areas.

6. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
 7. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
 8. Sweep concrete floors broom clean in unoccupied spaces.
 9. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Polish mirrors and glass, taking care not to scratch surfaces.
 10. Remove labels that are not permanent.
 11. Wipe surfaces of mechanical and electrical equipment, elevator equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
 12. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
 13. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
 14. Clean ducts, blowers, and coils if units were operated without filters during construction or that display contamination with particulate matter on inspection.
 15. Clean HVAC system in compliance with NADCA Standard 1992-01. Provide written report on completion of cleaning.
 16. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
 17. Leave Project clean and ready for occupancy.
- D. Construction Waste Disposal: Comply with waste disposal requirements in Section 01 73 00, "Execution of Work."
- E. Pest Control: Engage an experienced, licensed exterminator to make a final inspection and rid Project of rodents, insects, and other pests. Prepare and submit a report to CM.
- F. Comply with safety standards for cleaning. Do not burn waste materials. Do not bury debris or excess materials on VRE or Railroad property. Do not discharge volatile, harmful, or dangerous materials into drainage systems. Remove waste materials from Project site and dispose of lawfully.

3.02 REPAIR OF THE WORK

- A. Complete repair and restoration operations before requesting VRE review the Project for Substantial Completion.
- B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly

- adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.
- C. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.
 - D. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that already show evidence of repair or restoration.
 - E. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.
 - F. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.
 - G. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

END OF SECTION

SECTION 02 41 19 - SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Demolition and removal of selected portions of building or structure.
2. Demolition and removal of selected site elements.
3. Salvage of existing items to be reused or recycled.

B. Related Requirements:

1. Section 011000 "Summary of Work" for restrictions on use of the premises, Owner-occupancy requirements, and phasing requirements.
2. Section 013500 "Safety and Security Standards" for general protection and work procedures.
3. CSX Section 070220 "Demolish and Remove Existing Structure" in the Appendix for removal of railings that may have lead paint on them.
4. Section 311000 "Site Clearing" for site clearing and removal of above- and below-grade improvements not part of selective demolition.

1.3 DEFINITIONS

- A. Remove: Detach items from existing construction and dispose of them off-site unless indicated to be salvaged or reinstalled.
- B. Remove and Salvage: Detach items from existing construction, in a manner to prevent damage, and deliver to Owner ready for reuse.
- C. Remove and Reinstall: Detach items from existing construction, in a manner to prevent damage, prepare for reuse, and reinstall where indicated.
- D. Existing to Remain: Leave existing items that are not to be removed and that are not otherwise indicated to be salvaged or reinstalled.
- E. Dismantle: To remove by disassembling or detaching an item from a surface, using gentle methods and equipment to prevent damage to the item and surfaces; disposing of items unless indicated to be salvaged or reinstalled.

1.4 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.
- B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
 - 1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.5 PREINSTALLATION MEETINGS

- A. Predemolition Conference: Conduct conference at Project site.
 - 1. Inspect and discuss condition of construction to be selectively demolished.
 - 2. Review structural load limitations of existing structure.
 - 3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - 4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
 - 5. Review areas where existing construction is to remain and requires protection.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For refrigerant recovery technician.
- B. Engineering Survey: Submit engineering survey of condition of building.
- C. Proposed Protection Measures: Submit report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.
- D. Schedule of Selective Demolition Activities: Indicate the following:
 - 1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's on-site operations are uninterrupted.
 - 2. Interruption of utility services. Indicate how long utility services will be interrupted.
 - 3. Coordination for shutoff, capping, and continuation of utility services.
 - 4. Use of elevator and stairs.
 - 5. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.
- E. Predemolition Photographs or Video: Show existing conditions of adjoining construction, including finish surfaces, that might be misconstrued as damage caused by demolition operations. Comply with Section 013233 "Photographic Documentation." Submit before Work begins.
- F. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that

recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

- G. Warranties: Documentation indicating that existing warranties are still in effect after completion of selective demolition.
- H. The Contractor shall identify a Disposal Facility approved for the acceptance of creosote wood products and shall submit copies of any required licenses, certifications, or permits to VRE for approval.

1.7 CLOSEOUT SUBMITTALS

- A. Inventory: Submit a list of items that have been removed and salvaged.

1.8 NOT USED

1.9 FIELD CONDITIONS

- A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.
- B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
- C. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.
- D. Hazardous Materials: Except for the potential of lead paint in railing to be removed, it is not expected that hazardous materials will be encountered in the Work.
 - 1. If suspected hazardous materials are encountered other than noted above, do not disturb; immediately notify Architect and Owner. Retain "Hazardous Materials" Paragraph below if hazardous material remediation is part of the Work of this Contract. Consult a professional liability insurance carrier for current recommendations. Indemnification and a waiver of claims may be required from Owner as a condition for providing services related to hazardous material remediation. See "Hazardous Materials" Article in the Evaluations.
- E. Hazardous Materials: Present in buildings and structures to be selectively demolished.
 - 1. Hazardous material remediation is specified elsewhere in the Contract Documents.
 - 2. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified elsewhere in the Contract Documents.
- F. Historic Areas: Demolition and hauling equipment and other materials shall be of sizes that clear surfaces within historic spaces, areas, rooms, and openings, including temporary protection, by 12 inches (300 mm) or more.
- G. Storage or sale of removed items or materials on-site is not permitted.

- H. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

- 1. Maintain fire-protection facilities in service during selective demolition operations.

1.10 WARRANTY

- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials and using approved contractors so as not to void existing warranties. Notify warrantor before proceeding.
- B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

1.11 COORDINATION

- A. Arrange selective demolition schedule so as not to interfere with Owner's operations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- B. Standards: Comply with ASSE A10.6 and NFPA 241.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that utilities have been disconnected and capped before starting selective demolition operations.
- B. Review Project Record Documents of existing construction or other existing condition and hazardous material information provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in Project Record Documents.
- C. Verify that hazardous materials have been remediated before proceeding with building demolition operations.
- D. Survey of Existing Conditions: Record existing conditions by use of measured drawings and preconstruction photographs or video.

1. Inventory and record the condition of items to be removed and salvaged. Provide photographs or video of conditions that might be misconstrued as damage caused by salvage operations.
2. Before selective demolition or removal of existing building elements that will be reproduced or duplicated in final Work, make permanent record of measurements, materials, and construction details required to make exact reproduction.

3.2 PREPARATION

- A. Refrigerant: Before starting demolition, remove refrigerant from mechanical equipment according to 40 CFR 82 and regulations of authorities having jurisdiction.

3.3 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

- A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
- B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.
 1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
 2. Arrange to shut off utilities with utility companies.
 3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
 4. Disconnect, demolish, and remove plumbing, equipment, and components indicated on Drawings to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

3.4 PROTECTION

- A. Temporary Protection: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.

2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
 3. Protect existing finish work that is to remain or that is exposed during selective demolition operations.
 4. Cover and protect equipment that has not been removed.
 5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Section 015000 "Temporary Facilities and Controls."
- B. Temporary Shoring: Design, provide, and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.
1. Strengthen or add new supports when required during progress of selective demolition.
- C. Remove temporary barricades and protections where hazards no longer exist.

3.5 SELECTIVE DEMOLITION, GENERAL

- A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
 2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.
 3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
 4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
 5. Maintain fire watch during and for at least 2 hours after flame-cutting operations.
 6. Maintain adequate ventilation when using cutting torches.
 7. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
 8. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
 9. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
 10. Dispose of demolished items and materials promptly. Comply with requirements in Section 017419 "Construction Waste Management and Disposal."

- B. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
- C. Work in Historic Areas: Selective demolition may be performed only in areas of Project that are not designated as historic. In historic spaces, areas, and rooms, or on historic surfaces, the terms "demolish" or "remove" shall mean historic "removal" or "dismantling" as specified in Section 024296 "Historic Removal and Dismantling."
- D. Removed and Salvaged Items:
 - 1. Clean salvaged items.
 - 2. Pack or crate items after cleaning. Identify contents of containers.
 - 3. Store items in a secure area until delivery to Owner.
 - 4. Transport items to Owner's storage area designated by Owner.
 - 5. Protect items from damage during transport and storage.
- E. Removed and Reinstalled Items:
 - 1. Clean and repair items to functional condition adequate for intended reuse.
 - 2. Pack or crate items after cleaning and repairing. Identify contents of containers.
 - 3. Protect items from damage during transport and storage.
 - 4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.
- F. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.6 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS

- A. Concrete: Demolish in small sections. Using power-driven saw, cut concrete to a depth of at least 3/4 inch (19 mm) at junctures with construction to remain. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete. Neatly trim openings to dimensions indicated.
- B. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals using power-driven saw, and then remove concrete between saw cuts.
- C. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, and then remove masonry between saw cuts.
- D. Creosote treated wooden railroad ties: The work shall consist of the handling, loading, transporting, unloading, and disposal of creosote treated wooden railroad ties.
 - 1. The Contractor shall transport the creosote treated wood material directly to the Disposal Facility. Unloading and stock piling of the creosote treated wood at any location other than the approved Disposal facility is prohibited.

2. Cutting, chipping, burning, or any other type of processing of the creosote treated wood at locations other than the approved Disposal Facility is prohibited. The creosote treated wood shall not be sold or transferred to any third party other than the approved Disposal Facility.

3.7 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove demolition waste materials from Project site and dispose of them in an EPA-approved construction and demolition waste landfill acceptable to authorities having jurisdiction.
 1. Do not allow demolished materials to accumulate on-site.
 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
 3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
 4. Comply with requirements specified in Section 017419 "Construction Waste Management and Disposal."
- B. Burning: Do not burn demolished materials.

3.8 CLEANING

- A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 024119

SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.
- B. Related Requirements:
 - 1. Section 312000 "Earth Moving" for drainage fill under slabs-on-grade.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Concrete Subcontractor.
 - e. Special concrete finish Subcontractor.
 - 2. Review special inspection and testing and inspecting agency procedures for field quality control, concrete finishes and finishing, construction contraction and isolation joints, and joint-filler strips, semirigid joint fillers, anchor rod and anchorage device installation tolerances, steel reinforcement installation, and concrete protection.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Indicate amounts of mixing water to be withheld for later addition at Project site.
- C. Steel Reinforcement Shop Drawings: Placing Drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.
- D. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
 - 1. Location of construction joints not shown on the design drawings is subject to approval of the Engineer.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, manufacturer, and testing agency.
- B. Material Certificates: For each of the following, signed by manufacturers:
 - 1. Cementitious materials.
 - 2. Admixtures.
 - 3. Form materials and form-release agents.
 - 4. Steel reinforcement and accessories.
 - 5. Water stops.
 - 6. Curing compounds.
 - 7. Bonding agents.
 - 8. Adhesives.
 - 9. Semi-rigid joint filler.
 - 10. Joint-filler strips.
 - 11. Repair materials.
- C. Material Test Reports: For the following, from a qualified testing agency:
 - 1. Aggregates: Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
- D. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer licensed in the Commonwealth of Virginia, detailing fabrication, assembly, and support of formwork.
 - 1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.

- E. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.
- F. Field quality-control reports.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
 - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- B. Testing Agency Qualifications: An independent agency, , qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
 - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
 - 2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I. Testing agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician, Grade II.

1.8 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on concrete mixtures.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage
- B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

1.10 FIELD CONDITIONS

- A. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 1. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301 (ACI 301M).

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- B. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M), and as follows:
1. Maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
1. ACI 301 (ACI 301M).
 2. ACI 117 (ACI 117M).

2.2 FORM-FACING MATERIALS

- A. Smooth-Formed Finished Concrete: Form-facing panels that provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
1. Plywood, metal, or other approved panel materials.
 2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
 - a. High-density overlay, Class 1 or better.
 - b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
 - c. Structural 1, B-B or better; mill oiled and edge sealed.
 - d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.
 3. Overlaid Finnish birch plywood.
- B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that produce surfaces with gradual or abrupt irregularities not exceeding

specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

- D. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
- E. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.
- F. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.
- G. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
 - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
- H. Form Ties: Factory-fabricated, removable or snap-off glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
 - 1. Furnish units that leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
 - 2. Furnish ties that, when removed, leave holes no larger than 1 inch (25 mm) in diameter in concrete surface.
 - 3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.3 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- C. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, plain, fabricated from as-drawn steel wire into flat sheets.

2.4 REINFORCEMENT ACCESSORIES

- A. Epoxy-Coated Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, ASTM A 775/A 775M epoxy coated.
- B. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 775M.
- C. Zinc Repair Material: ASTM A 780/A 780M.
- D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place. Manufacture bar supports from steel

wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

2.5 CONCRETE MATERIALS

- A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.
- B. Cementitious Materials:
 1. Portland Cement: ASTM C 150/C 150M, Type II .
 2. Fly Ash: ASTM C 618, Class F or C.
 3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
 4. Blended Hydraulic Cement: ASTM C 595/C 595M, Type IS, Portland blast-furnace slag Type IP, Portland-pozzolanor Type IL, Portland-limestone cement.
 5. Silica Fume: ASTM C 1240, amorphous silica.
- C. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 1Ncoarse aggregate or better, graded. Provide aggregates from a single source.
 1. Maximum Coarse-Aggregate Size: Not exceeding 3/4 of minimum clear space between bars and between bars and forms, nor larger than 1/5 of least dimensions between the forms. Design the mixes with 3/4-inch maximum size, except maximum 1-1/2 inch size for foundations and maximum 3/8 inch size at congested reinforcing or thin sections, when approved by the Engineer.
 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- D. Lightweight Aggregate: ASTM C 330/C 330M, 3/4-inch (19-mm nominal maximum aggregate size).
- E. Air-Entraining Admixture: ASTM C 260/C 260M.
- F. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 2. Retarding Admixture: ASTM C 494/C 494M, Type B.
 3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
- G. Water: ASTM C 94/C 94M and potable.

2.6 WATERSTOPS

- A. Flexible Rubber Waterstops: CE CRD-C 513, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Williams Products, Inc.
 - 2. Profile: Ribbed with center bulb and Ribbed without center bulb.
 - 3. Dimensions: For walls, flat ribbed type, minimum 6 inches width by 3/8 inch thick at center with minimum 7 ribs each side of each flange. For slabs, ribbed center bulb type, minimum 9 inches wide by 3/8 inch thick next to bulb, minimum 9 ribs on each side of each flange, bulb minimum 1/2 inch ID and 7/8 inch OD; non-tapered.
- C. Flexible PVC Waterstops: CE CRD-C 572, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. BoMetals, Inc.
 - b. Sika Greenstreak.
 - 2. Profile: Ribbed with center bulb and Ribbed without center bulb
 - 3. Dimensions: For walls, ribbed without center bulb, minimum 6 inches width by 3/8-inch thick at center with minimum 7 ribs each side of each flange. For slabs, ribbed with center bulb type, minimum 9 inches wide by 3/8-inch thick next to bulb, minimum 9 ribs on each side of each flange, bulb minimum 1/2 inch ID and 7/8 inch OD; non-tapered.

2.7 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
 - 1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. BASF Corp. - Construction Chemicals.
 - b. Brickform; a division of Solomon Colors.
 - c. Dayton Superior.
 - d. Euclid Chemical Company (The); an RPM company.
 - e. Kaufman Products, Inc.
 - f. Nox-Crete Products Group.
 - g. Sika Corporation.
 - h. SpecChem, LLC.
 - i. TK Products.

- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Corp. - Construction Chemicals.
 - b. Dayton Superior.
 - c. Euclid Chemical Company (The); an RPM company.
 - d. Kaufman Products, Inc.
 - e. Nox-Crete Products Group.
 - f. Right Pointe.
 - g. SpecChem, LLC.
 - h. TK Products.
 - i. Vexcon Chemicals Inc.
 - j. W.R. Meadows, Inc.

2.8 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.
- B. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-dispersible, acrylic emulsion or styrene butadiene.
- C. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
 - 1. Types I and II, non-load bearing or Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.9 CONCRETE MIXTURES, GENERAL

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301 (ACI 301M).
 - 1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.
- B. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing, high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

2.10 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Footings: Normal-weight concrete.

1. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
2. Maximum W/C Ratio: 0.50.
3. Slump Limit: 4 inches (100 mm). 8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture, plus or minus 1 inch (25 mm).
4. Air Content: 5.5 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch (38-mm) nominal maximum aggregate size.

B. Foundation Walls: Normal-weight concrete.

1. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
2. Maximum W/C Ratio: 0.50.
3. Slump Limit: 4 inches (100 mm). 8 inches (200 mm) for concrete with verified slump of 2 to 4 inches (50 to 100 mm) before adding high-range water-reducing admixture or plasticizing admixture, plus or minus 1 inch (25 mm).
4. .
5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 3/4-inch (19-mm) nominal maximum aggregate size.

C. Slabs-on-Grade: Normal-weight concrete.

1. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
2. Maximum W/C Ratio: 0.45.
3. Minimum Cementitious Materials Content: 540 lb/cu. yd. (320 kg/cu. m).
4. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).
5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 3/4-inch (19-mm) nominal maximum aggregate size.

D. Suspended Slabs: Normal-weight concrete.

1. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
2. Maximum W/C Ratio: 0.50.
3. Minimum Cementitious Materials Content: 540 lb/cu. yd. (320 kg/cu. m).
4. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).
5. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 3/4-inch (19-mm) nominal maximum aggregate size.
- 6.

E. Suspended Slabs (Roof Slab): Lightweight concrete.

1. Minimum Compressive Strength: 3000 psi (20.7 MPa at 28 days.
2. Calculated Equilibrium Unit Weight: 115 lb/cu. ft. (1842 kg/cu. m) plus or minus 3 lb/cu. ft. (48.1 kg/cu. m) as determined by ASTM C 567/C 567M.
3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).
4. Air Content: 6 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size greater than 3/8 inch (10 mm).
5. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

2.11 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.12 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
 1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 2. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301 (ACI 301M), to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.
- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117 (ACI 117M).
- C. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:
 1. Class A, 1/8 inch (3.2 mm) for smooth-formed finished surfaces.

2. Class B, 1/4 inch (6 mm) for rough-formed finished surfaces.
- D. Construct forms tight enough to prevent loss of concrete mortar.
- E. Construct forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 1. Install keyways, recesses, and the like, for easy removal.
 2. Do not use rust-stained steel form-facing material.
- F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
- G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- H. Chamfer exterior corners and edges of permanently exposed concrete.
- I. Form openings, chases, offsets, sinkages, keyways, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEM INSTALLATION

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.

3.3 REMOVING AND REUSING FORMS

- A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
 2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material are not acceptable for exposed surfaces. Apply new form-release agent.
- C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.4 SHORING AND RESHORING INSTALLATION

- A. Comply with ACI 318 (ACI 318M) and ACI 301 (ACI 301M) for design, installation, and removal of shoring and reshoring.
1. Do not remove shoring or reshoring until measurement of slab tolerances is complete.
- B. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.5 STEEL REINFORCEMENT INSTALLATION

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.
- C. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- D. Install welded-wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

3.6 JOINTS

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

- B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by the Engineer.
1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
 2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
 3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
 6. Use a bonding agent, where indicated, at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 7. Use epoxy-bonding adhesive, where indicated, at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:
1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3.2-mm-) wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
- D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.
 2. Terminate full-width joint-filler strips not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface where joint sealants, specified in Section 079200 "Joint Sealants," are indicated.
 3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
- E. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.7 WATERSTOP INSTALLATION

- A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

3.8 CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections are completed.
- B. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301 (ACI 301M).
 - 1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.
- C. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
 - 1. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - 2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301 (ACI 301M).
 - 3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.
- D. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
 - 1. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - 2. Maintain reinforcement in position on chairs during concrete placement.
 - 3. Screed slab surfaces with a straightedge and strike off to correct elevations.
 - 4. Slope surfaces uniformly to drains where required.
 - 5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

3.9 FINISHING FORMED SURFACES

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
 - 1. Apply to concrete surfaces not exposed to public view.
- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and

defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to public view, or to be covered with a coating or covering material applied directly to concrete.
- C. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.10 FINISHING FLOORS AND SLABS

- A. General: Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighen until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
1. Apply a trowel finish to surfaces to be covered with roofing rigid insulation and membrane
 2. Finish surfaces to the following tolerances, according to ASTM E 1155 (ASTM E 1155M), for a randomly trafficked floor surface:
 - a. Specified overall values of flatness, F(F) 25; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and of levelness, F(L) 15.
 3. Finish and measure surface, so gap at any point between concrete surface and an unveled, freestanding, 10-ft.- (3.05-m-) long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/4 inch (6 mm).
- C. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.
1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

3.11 MISCELLANEOUS CONCRETE ITEM INSTALLATION

- A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations:
 - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 - 2. Construct concrete bases 8 inches (200 mm) high unless otherwise indicated, and extend base not less than 6 inches (150 mm) in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support.
 - 3. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
 - 6. Prior to pouring concrete, place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 7. Cast anchor-bolt insert into bases. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Surface finish to conform to Section 055133.

3.12 CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 305.1 (ACI 305.1M) for hot-weather protection during curing.
- B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for remainder of curing period.
- D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
- E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.

- b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.
- 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
 - b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
 - c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies does not interfere with bonding of floor covering used on Project.
- 3. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.13 JOINT FILLING

- A. Prepare, clean, and install joint filler according to manufacturer's written instructions.
 - 1. Defer joint filling until concrete has aged at least one month. Do not fill joints until construction traffic has permanently ceased.
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.
- C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.14 CONCRETE SURFACE REPAIRS

- A. Defective Concrete: Repair and patch defective areas when approved by Engineer. Remove and replace concrete that cannot be repaired and patched to Engineer's approval at no additional cost to VRE
- B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part Portland cement to 2-1/2 parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.

- C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension to solid concrete. Limit cut depth to 3/4 inch (19 mm). Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
 2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar matches surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Architect.
- D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
 2. After concrete has cured at least 14 days, correct high areas by grinding.
 3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
 4. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 5. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
 6. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
- E. Perform structural repairs of concrete, subject to Engineer's approval, using epoxy adhesive and patching mortar.

- F. Repair materials and installation not specified above may be used, subject to Engineer's approval.

3.15 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- C. Inspections:
 - 1. Steel reinforcement placement.
 - 2. Steel reinforcement welding.
 - 3. Headed bolts and studs.
 - 4. Verification of use of required design mixture.
 - 5. Concrete placement, including conveying and depositing.
 - 6. Curing procedures and maintenance of curing temperature.
 - 7. Verification of concrete strength before removal of shores and forms from beams and slabs.
- D. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:
 - 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd. (4 cu. m), but less than 25 cu. yd. (19 cu. m), plus one set for each additional 50 cu. yd. (38 cu. m) or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 - 2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 - 3. Air Content: ASTM C 231/C 231M, pressure method, for normal-weight concrete; ASTM C 173/C 173M, volumetric method, for structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - 4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below or 80 deg F (27 deg C) and above, and one test for each composite sample.
 - 5. Unit Weight: ASTM C 567/C 567M, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - 6. Compression Test Specimens: ASTM C 31/C 31M.
 - a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.

- b. Cast and field cure two sets of two standard cylinder specimens for each composite sample.
- 7. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
 - a. Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days.
 - b. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
- 8. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
- 9. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
- 10. Test results shall be reported in writing to Engineer, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- 11. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.
- 12. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Architect.
- 13. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- 14. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 033000

SECTION 03 35 00 – Shotcrete and Permanent Concrete Facing**PART 1 – GENERAL****1.1 DESCRIPTION**

- A. The Work shall consist of designing and constructing shotcrete facing and permanent concrete facing for soil nail retaining walls as specified herein and shown on the Plans. Shotcrete facing and wall drainage work consists of furnishing all materials and labor required for placing and securing geocomposite drainage material, connection pipes, weepholes and horizontal drains (if required), reinforcing steel and shotcrete for the temporary shotcrete construction facing, rail head bearing plates and nuts, and the permanent concrete facing and reinforcing steel for the soil nail walls shown on the Plans or working drawings. The Work shall include any preparatory trimming and cleaning of soil/rock surfaces and shotcrete cold joints to receive new shotcrete.
- B. Shotcrete shall comply with the requirements of Section 412 of the 2016 VDOT Road and Bridge Specifications, except as otherwise specified. The use of fly ash will not be permitted in shotcrete. Shotcrete shall consist of any application of one or more layers of concrete conveyed through a hose and pneumatically projected at a high velocity against a prepared surface.
- C. Concrete facing construction shall comply with the requirements in Section 404 of the 2016 VDOT Road and Bridge Specifications and shall be cast-in-place. Precast concrete facing will not be allowed. Soil nails and wall excavation are covered by Section 32-50-00 “Permanent Soil Nails”.

1.2 DESIGN CRITERIA

- A. Soil nail walls shall be designed and constructed in accordance with the 5th Edition of the AASHTO LRFD Bridge Design Specifications, FHWA-IF-03-017 “Geotechnical Engineering Circular No. 7”, and the Specifications except as otherwise noted herein. Alternative design criteria may be considered if approved by the Engineer. See Section 32-50-00 “Permanent Soil Nails” for required Factors of Safety that shall be used for the design of the soil nail wall.

1.3 SUBMITTALS

- A. Before starting the respective operation or incorporating materials referenced below, submit the following information to the Engineer for review and approval:
 - 1. Written documentation of the nozzleman's qualifications including proof of certification. If the nozzleman is currently certified by ACI, the requirement of making test panels will be waived.
 - 2. Proposed method of shotcrete placement and of controlling and maintaining facing alignment and location and shotcrete thickness.
 - 3. Shotcrete mix design including:

Type of Portland cement.

Aggregate source and gradation.

Proportions of mix by weight and water/cement ratio.

Proposed admixtures, manufacturer, dosage, technical literature.

Previous strength test results for the shotcrete mix completed within one year of the start of shotcreting may be submitted for initial verification of the required compressive strengths at start of production work.

4. Certificates of Compliance for bearing plates, nuts, drainage aggregates and PVC drain piping.
 5. Design calculations and drawings for the temporary shotcrete construction facing and permanent concrete facing. All working drawings, shop plans, and design calculations shall be signed and sealed by a Professional Engineer licensed to practice engineering in the Commonwealth of Virginia. The proposed design shall satisfy the design parameters and requirements in the plans and specifications. Complete design calculations shall include the most critical geometry and loading combination for each design section that exists during construction and at the end of construction. Approval of the Contractor's working drawings, shop plans, and design calculations shall not relieve the Contractor of any of his responsibility under the contract for the successful completion of the work.
 6. Formwork dimensions for casting the concrete facing over the shotcrete construction facing. Include details for form work connections to the shotcrete facing and/or nails (if applicable), proposed concrete placement method and placement rates, and accompanying structural calculations verifying the structural adequacy of the formwork, connections, and shotcrete facing and/or nails to support the loading induced by the fluid concrete. When anchors embedded into the shotcrete facing will be used to support the single sided face form, include calculations illustrating the anchor design load (calculated as the design concrete fluid pressure times the anchor tributary area). The structural calculations shall be signed and sealed by a Professional Engineer licensed to practice engineering in the Commonwealth of Virginia.
- B. Upon delivery to the project site, provide Certified mill test results for all reinforcing steel specifying the minimum ultimate strength, yield strength, elongation and chemical composition.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Shotcrete shall conform to Section 412 of the 2016 VDOT Road and Bridge Specifications except that the use of fly ash will not be permitted.
- B. Deformed reinforcing steel bars shall conform to Section 223 of the 2016 VDOT Road and Bridge Specifications.
- C. Welded wire fabric shall conform to Section 223 of the 2016 VDOT Road and Bridge

Specifications.

- D. Bearing plates shall conform to AASHTO M-183 or equivalent.
- E. Nuts shall conform to AASHTO M-291, Grade B, Hexagonal, or equivalent, fitted with beveled washer or spherical seat to provide uniform bearing.
- F. Geocomposite Drain Strip Miradrain 6000 or Amerdrain 500, or approved equal

Geocomposite drain strips shall be provided in rolls wrapped with a protective covering and stored in a manner which protects the fabric from mud, dirt, dust, debris, and shotcrete rebound. Protective wrapping shall not be removed until immediately before the drain strip is installed. Extended exposure to ultraviolet light shall be avoided. Each roll of drain strip in the shipment shall be labeled to identify the production run.
- G. PVC pipe shall conform to Section 232 of the 2016 VDOT Road and Bridge Specifications.
- H. Concrete in the permanent concrete facing shall have a minimum compressive cylinder strength at 28 days equal to 5,000 psi. All concrete shall be in accordance with Appendix A, Section 070105 of the Specifications. The use of fly ash is not permitted in hydraulic cement concrete mix.

PART 3 – INSTALLATION

3.1 CONSTRUCTION REQUIREMENTS

A. Site Drainage Control

- 1. Provide positive control and discharge of all surface water that will affect shotcreting at time of construction. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water. Upon substantial completion of shotcreting activities, remove surface water control pipes or conduits from the site. Alternatively, with the approval of the Engineer, pipes or conduits that are left in place, may be fully grouted and abandoned or left in a way that protects that structure and all adjacent facilities from mitigation of fines through the pipe or conduit and potential ground loss.
- 2. Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during shotcreting. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Capture surface water runoff flows and flows from existing subsurface drainage structures independently of the wall drainage network and convey them to an outfall structure or storm sewer, as approved by the Engineer.

B. Wall Drainage Network

- 1. Install and secure all elements of the wall drainage network as shown on the Plans, working drawings, specified herein, or as required by the Engineer to suit the site conditions. The drainage network shall consist of installing geocomposite drain strips, PVC connector pipes and weep holes, pipes as indicated in the Plans, working drawings, or as directed by the

Engineer. Exclusive of the wall footing drains, all elements of the drainage network shall be installed prior to shotcreting.

2. Unanticipated subsurface drainage features exposed in the excavation cut face shall be captured independently of the drainage network and shall be mitigated prior to shotcrete application.

C. Geocomposite Drain Strips

1. Install geocomposite drain strips per the manufacturer's requirements. Install geocomposite drain strips centered between the columns of nails. The drain strips shall be placed with the geotextile side against the ground. Secure the strips to the excavation face and prevent shotcrete from contaminating the ground side of geotextile. Drain strips will be continuous. Splices shall be made with a 12 inch minimum overlap such that the flow of water is not impeded. Repair damage to the geocomposite drain strip, which may interrupt the flow of water.

D. Connection Pipes

1. Install connection pipes as shown on the Plans, working drawings, or as directed by the Engineer. Connection pipes are lengths of solid PVC pipe installed to direct water from the geocomposite drain strips into weep holes through the exposed face of the wall. Connect the connection pipes to the drain strips using either prefabricated drain grates or using the alternative connection method described below. Install the drain grate per the manufacturer's recommendations. The joint between the drain grate and the drain strip and the discharge end of the connector pipe shall be sealed to prevent shotcrete intrusion. Connection pipes that end at the toe drain shall be extended to the edge of the drain.
2. The alternative acceptable method for connection of the connector pipe to the drain strip involves cutting a hole slightly larger than the diameter of the pipe into the strip plastic core but not through the geotextile. Wrap both ends of the connection pipe in geotextile in a manner that prevents migration of fines through the pipe. Tape or seal the inlet end of the pipe where it penetrates the drain strip and the discharge end of the connector pipe in a manner that prevents penetration of shotcrete into the drain strip or pipe. To assure passage of groundwater from the drain strip into the connector pipe, slot the inlet end of the connector pipe at every 45 degrees around the perimeter of the pipe to a depth of 1/4 inch. The alternative method for connection of connector pipe must be approved by geocomposite drain manufacturer to ensure the proper function of the drain.

E. Construction Joints – Shotcrete Facing

1. Taper construction joints uniformly toward the excavation face over a minimum distance equal to the thickness of the shotcrete layer. Provide a minimum reinforcement overlap at reinforcement splice joints as determined by the Contractor's design. Clean and wet the surface of a joint before adjacent shotcrete is applied. Where shotcrete is used to complete the top ungrouted zone of the nail drill hole near the face, to the maximum extent practical, clean and dampen the upper grout surface to receive shotcrete, similar to a construction joint.

F. Joints – Cast-in-Place Concrete Facing

1. Provide contraction joints of not more than 10 feet intervals, horizontal and vertical. Reinforcing steel shall be continuous through the joint.
 - a. All construction joints shall include a shear key of not less than 2 inch by 1 1/2 inch and a nonmetal waterstop. Reinforcing steel shall be continuous through the joint.
 - b. Expansion joints shall be provided at intervals not to exceed 80 feet. Joint shall be filled per Section 404.05 of the 2016 VDOT Road and Bridge Specifications and include a nonmetal waterstop.

G. Finish

1. Shotcrete finish shall be either an undisturbed gun finish as applied from the nozzle or a rough screeded finish. Remove shotcrete extending into the concrete finish face section beyond the tolerances shown on the Plans or specified herein.

H. Attachment of the Nail Head Bearing Plate and Nut

1. Attach a bearing plate and nut to each nail head as required per the Contractor's approved soil nail wall submittal. While the shotcrete is still plastic and before its initial set, uniformly seat the plate on the shotcrete by hand wrench tightening the nut. Where uniform contact between the plate and the shotcrete cannot be provided, set the plate in a bed of grout. After the grout has set for 24 hours, hand wrench tighten the nut. Ensure bearing plates with headed studs are in intimate contact with the construction facing and the studs are located within the tolerances shown on the Plans, working drawings, or specified herein. Bearing plate and nut shall be protected from corrosion by placing a minimum of 2 inches of concrete or by approved epoxy coating system.

I. Curing

1. Shotcrete shall be moist cured. Curing is not required for temporary construction facings to be covered by a concrete facing or whose service life is less than 36 months.

J. Backfilling Behind Wall Facing

1. Compact backfill within 5 feet behind the wall facing using light mechanical tampers.

K. Concrete Form Connection to Shotcrete Facing

1. When mechanical, grouted, or epoxied anchors embedded into the shotcrete facing are used to support a one-sided concrete face form, perform pullout testing of the embedded anchors in accordance with ASTM C900 and as modified herein. Perform pullout testing of installed anchors prior to attachment of the face form. Select test anchor locations to be representative of the full wall surface area to be covered.

2. For facing areas up to 5,500 sq ft, perform a minimum of three flexure/shear pullout tests with the anchor located approximately mid-span between two adjacent nail heads and with the nail heads or other reaction points located approximately one-half the nail spacing from the anchor. For facing areas in excess of 5,500 sq ft, perform one additional flexure/shear pullout test for each additional 2,750 sq ft of face area. Test these anchors to 1.5 times their required design load (calculated as the design concrete fluid pressure times the anchor tributary area).
3. Perform local punching shear pullout testing on two percent of the installed anchors. Place the load reaction support no closer to the edge of the anchor than the embedment depth of the anchor into the construction facing. Test these anchors to 2.0 times their required design load.
4. Modify the anchor and/or face form support system if the tested anchors do not meet the above test acceptance criteria. Modified anchor installation will require re-testing in accordance with the above testing criteria. Cost of anchor pullout testing is incidental to the work.

L. Cast-in-Place Concrete Facing

1. At the completion of the sequenced construction, and where required, construct cast-in-place structural facing in accordance with the provisions of Section 404 of the 2016 VDOT Road and Bridge Specifications and the Contract Plans.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION

SECTION 04 21 00 - CLAY UNIT MASONRY- THIN BRICK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Thin Brick
2. Mortar
3. Cleaning
4. Embedded Flashing
5. Weep Screeds
6. Expansion Joints
7. Miscellaneous masonry accessories.

B. Related Requirements:

1. Section 06 16 00 "Sheathing" for wall sheathing in walls.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Preparation instructions and recommendations
2. Storage, handling requirements and recommendations
3. Installation methods

B. Shop Drawings: For the following:

1. Masonry Units: Show sizes, profiles, coursing, color arrangement, junctions with other related components and locations of special shapes.
2. Locate and detail expansion detail and control joint details.
3. Fabricated Flashing: Detail corner units and other special applications.

C. Samples for Initial Selection:

1. Furnish no less than five individual thin brick samples each to match the existing station House and the thin brick colors indicated on the drawing for the new work.
2. Colored mortar.
3. Flashing and Weep screeds.

D. Samples for Verification: For each type and color of the following:

1. Clay face brick: To match existing Station House Color 1 and Color 2 (Tower accent banding)
2. Special brick shapes.
3. Mortar. Make Samples using same sand and mortar ingredients to be used on Project.
4. Flashing and Weep Screeds.
5. Accessories embedded in masonry.

1.5 INFORMATIONAL SUBMITTALS

A. List of Materials Used in Constructing Mockups: List generic product names together with manufacturers, manufacturers' product names, model numbers, lot numbers, batch numbers, source of supply, and other information as required to identify materials used. Include mix proportions for mortar and grout and source of aggregates.

1. Submittal is for information only. Receipt of list does not constitute approval of deviations from the Contract Documents unless such deviations are specifically brought to the attention of Architect and approved in writing.

B. Qualification Data: For testing agency.

C. Material Certificates: For each type and size of the following:

1. Masonry units.
 - a. Include data on material properties material test reports substantiating compliance with requirements.
 - b. For brick, include size-variation data verifying that actual range of sizes falls within specified tolerances.
 - c. For exposed brick, include test report for efflorescence according to ASTM C67.
2. Cementitious materials. Include name of manufacturer, brand name, and type.
3. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
4. Metal accessories.

D. Mix Designs: For each type of mortar: Veneer Mortar, Pointing Mortar. Include description of type and proportions of ingredients.

1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C109/C109M for compressive strength, ASTM C1506 for water retention, and ASTM C91/C91M for air content.
2. Include test reports, according to ASTM C1019, for grout mixes required to comply with compressive strength requirement.

- E. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements. Cold weather additives shall not be used in thin brick mortar mix.

1.6 QUALITY ASSURANCE

- A. Masonry standard: Comply with Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6 unless modified by requirements in the Contract Documents.
- B. Comply with all applicable codes, regulations, and standards. Where provision of applicable codes, regulations, and standards conflict with requirements of this section, the more demanding shall govern.
- C. Manufacturer Qualifications:
 - 1. Obtain materials from one manufacturer to ensure compatibility.
 - 2. Obtain materials from company specializing in manufacturing products specified in this section with a minimum 5 years documented experience.
- D. Installer Qualifications:
 - 1. Proof of a minimum of five years experience with related thin masonry installations.
 - 2. At least one supervisory journeyman who shall always be present during execution of work, who shall be thoroughly familiar with design requirement, type of materials being installed, reference standards and other requirements, and who shall direct all work performed at jobsite.
- E. Material Certificates: Prior to delivery, submit to Architect/Engineer certificates indicating compliance with the applicable specifications for Thin Brick Grades, Types or Classes included in these specifications.
- F. Thin Brick Test Reports: Submit test reports substantiating compliance with requirements: Sample and test in accordance with ASTM C 1088, Grade Exterior.
 - 1. Testing and reports shall be completed by an independent laboratory.
 - a. Test reports for each type of thin brick shall be submitted to the Architect/Engineer for review.
 - b. Thin Brick Test reports shall indicate:
 - 1) 2-hour cold water absorption
 - 2) 5-hour boil absorption
 - 3) Saturation coefficient
 - 4) Initial rate of absorption
 - 5) Efflorescence.
- G. Costs of Tests: Cost of tests shall be borne by the purchaser, unless tests indicate that units do not conform to the requirements of the specifications, in which case cost shall be borne by the seller.
- H. Shop drawings: Submit individual drawings to be approved by architect for special shaped thin brick units.

- D. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
1. Build mockups for each type of exposed unit masonry construction typical exterior wall in sizes approximately 72 inches long by 72 inches high by full thickness, including corner units and accessories.
 - a. Include a sealant-filled joint at least 16 inches long in exterior wall mockup.
 - b. Include lower corner of louver opening at upper corner of exterior wall mockup. Make opening approximately 12 inches wide by 16 inches high.
 - c. Include through-wall flashing installed for a 24-inch length in corner of exterior wall mockup approximately 16 inches down from top of mockup, with a 12-inch length of flashing left exposed to view (omit masonry above half of flashing).
 - d. Include metal studs, sheathing, water-resistive barrier sheathing joint-and-penetration treatment air barrier, veneer anchors, flashing, cavity drainage material, and weep holes in exterior masonry-veneer wall mockup.
 2. Masonry is to match existing Station House to existing, erect mockups adjacent and parallel to existing surface.
 3. Clean one-half of exposed faces of mockups with masonry cleaner as indicated.
 4. Protect accepted mockups from the elements with weather-resistant membrane.
 5. Approval of mockups is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
 - a. Approval of mockups is also for other material and construction qualities specifically approved by Architect in writing.
 - b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.
- B. Deliver preblended, dry mortar mix in moisture-resistant containers. Store preblended, dry mortar mix in delivery containers on elevated platforms in a dry location or in covered weatherproof dispensing silos.
- C. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.8 FIELD CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.

1. Extend cover a minimum of 24 inches down both sides of walls, and hold cover securely in place.
- B. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove mortar and soil that come in contact with such masonry.
1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
 2. Protect sills, ledges, and projections from mortar droppings.
 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
 4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- C. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6 and material manufacturers for environmental conditions
1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.
- D. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6 and manufacturer's instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Brick Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but not limited to, the following:
- a. Belden Brick Company
 - b. Endicott Clay Products Company
 - c. Glen-Gerry Corporation
- B. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.
- C. Accepted Mortar Manufacturers: Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source.

2.2 THIN BRICK

- A. General: Provide shapes indicated and as follows, with exposed surfaces matching finish and color of exposed faces of adjacent units:
1. Provide special shapes for applications where stretcher units cannot accommodate special conditions, including those at corners, movement joints, bond beams, sashes, and lintels.
 2. Provide special shapes for applications requiring brick of size, form, color, and texture on exposed surfaces that cannot be produced by sawing.
 3. Provide special shapes for applications where shapes produced by sawing would result in sawed surfaces being exposed to view.
- B. Thin Brick: complying with ASTM C1088, Exterior Grade.
1. Grade: SW.
 2. Type: TBX.
 3. Initial Rate of Absorption: Less than 30 g/30 sq. in. per minute when tested according to ASTM C67.
 4. Efflorescence: Provide brick that has been tested according to ASTM C67 and is rated "not effloresced."
 5. Size (Actual Dimensions): 3/4 inches wide by 2-1/4 inches high by 7-5/8 inches long
 6. Color and Texture: Color #1 (Field) Match existing Station House brick veneer, samples approved by Architect. Color #2 (Accent band) as selected and approved by Architect.

2.3 MORTAR MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.
1. Alkali content shall not be more than 0.1 percent when tested according to ASTM C114.
- B. Hydrated Lime: ASTM C207, Type S.
- C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing with metal oxide pigments.
- D. Mortar Cement: ASTM C270, Type N1329/C1329M.
- E. Colored Cement Products: Packaged blend made from portland cement and hydrated lime and mortar pigments, all complying with specified requirements, and containing no other ingredients.
1. Colored Portland Cement-Lime Mix:
 - a. The Basis- of-Design Manufacturer by Color Mortar Blend by Glen-Gery Corporation.
 2. Formulate blend as required to produce color indicated or, if not indicated, as selected from manufacturer's standard colors.

3. Pigments shall not exceed 10 percent of portland cement by weight.

F. Sand for Mortar shall conform to: ASTM C144.

1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
2. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.

G. Water: Potable.

2.4 EMBEDDED FLASHING MATERIALS

A. Metal Flashing: Provide metal flashing complying with SMACNA's "Architectural Sheet Metal Manual" and as follows:

1. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.016 inch thick.
2. Fabricate continuous flashings in sections 96 inches long minimum, but not exceeding 12 feet. Provide splice plates at joints of formed, smooth metal flashing.
3. Fabricate through-wall flashing with drip edge unless otherwise indicated. Fabricate by extending flashing 1/2 inch out from wall, with outer edge bent down 30 degrees.
4. Fabricate through-wall flashing with sealant stop unless otherwise indicated. Fabricate by bending metal back on itself 3/4 inch at exterior face of wall and down into joint 1/4 inch to form a stop for retaining sealant backer rod.
5. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.

B. Application: Unless otherwise indicated, use the following:

1. Where flashing is indicated to receive counterflashing, use metal flashing.
2. Where flashing is indicated to be turned down at or beyond the wall face, use metal flashing.
3. Where flashing is partly exposed and is indicated to terminate at the wall face, use metal flashing with a drip edge.
4. Where flashing is fully concealed, use metal flashing.

C. Sealants for Sheet Metal Flashings: As specified compatible with the other thin brick wall materials."

1. Elastomeric Sealant: ASTM C920, chemically curing urethane sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and remain watertight.

D. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

2.5 MISCELLANEOUS MASONRY ACCESSORIES

- A. Compressible Filler: Premolded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene.

2.6 MASONRY CLEANERS

- A. Proprietary Acidic Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar/grout stains, efflorescence, and other new construction stains from new masonry without discoloring or damaging masonry surfaces. Use product expressly approved for intended use by cleaner manufacturer and manufacturer of masonry units being cleaned.

2.7 MORTAR MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
 - 1. Do not use calcium chloride in mortar or grout.
 - 2. Use portland cement-lime mortar unless otherwise indicated.
- B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
- C. Mortar for Unit Masonry: Comply with ASTM C270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated.
 - 1. For exterior, above-grade, nonload-bearing wall use Type S.
- D. Pigmented Mortar: Use colored cement product.
 - 1. Pigments shall not exceed 10 percent of portland cement by weight.
 - 2. Pigments shall not exceed 5 percent of mortar cement by weight.
 - 3. Mix to match existing color of Station House mortar.
 - 4. Application: Use pigmented mortar for exposed mortar joints with the following units:
 - a. Thin brick.
- E. Colored-Aggregate Mortar: Produce required mortar color by using colored aggregates and natural color or white cement as necessary to produce required mortar color.
 - 1. Mix to match existing Station House.
 - 2. Application: Use colored-aggregate mortar for exposed mortar joints with the following units:
 - a. Clay face brick.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
 - 2. Verify that foundations are within tolerances specified.
 - 3. Verify that reinforcing dowels are properly placed.
 - 4. Verify that substrates are free of substances that impair mortar bond.
- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Thickness: Build walls and other masonry construction to full thickness shown.
- B. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.
- C. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures. Mix units from several pallets or cubes as they are placed.
- D. Matching Existing Masonry: Match coursing, bonding, color, and texture of existing station House masonry.
- E. Wetting of Brick: Wet brick before laying if initial rate of absorption exceeds 30 g/30 sq. in. per minute when tested according to ASTM C67. Allow units to absorb water so they are damp but not wet at time of laying.

3.3 TOLERANCES

- A. Dimensions and Locations of Elements:
 - 1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch or minus 1/4 inch.
 - 2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch.
 - 3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch in a story height or 1/2-inch total.
- B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet, or 1/2-inch maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2-inch maximum.
3. For vertical lines and surfaces, do not vary from plumb by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2-inch maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2-inch maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2-inch maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet or 1/2-inch maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch except due to warpage of masonry units within tolerances specified for warpage of units.

C. Joints:

1. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch.
2. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch or minus 1/4 inch.
3. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch.
4. For exposed bed joints and head joints of stacked bond, do not vary from a straight line by more than 1/16 inch from one masonry unit to the next.

3.4 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.
- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less-than-nominal 4-inch horizontal face dimensions at corners or jambs.
- C. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- E. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.

3.5 FLASHING AND WEEP SCREENS

- A. General: Install embedded flashing and weep screens in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated.
- B. Install flashing as follows unless otherwise indicated:
 - 1. Head flashing should extend to the exterior wall face to form a drip with the back edge turned up at least 3 ½" vertically. The water resistant barrier should lap over the vertical flashing
 - 2. Sill flashing should to the exterior wall face to form a drip edge with the back edge turned down at least 2" vertically. The vertical flashing will lap over the water resistant barrier.
 - 3. Jamb flashing (casing bead) should extend to the exterior wall face to form the vertical edge of the 3/8" opening for the sealant and backer rod. The flashing will lap over the water resistant barrier.
- C. Install weep screeds as follows unless otherwise indicated:
 - 1. Foundation weep screeds should extend to exterior wall face to form a drip with the back edge turned up at least 3 ½" vertically. The water resistant barrier should lap over the weep screed.
- D. Place the drainage mat between the cement board and weather resistant to comply with configuration requirements for cavity drainage material.
- E. Place the Weather resistant barrier behind the cement board.

3.6 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
 - 1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
 - 2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
 - 3. Protect nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.

4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
5. Clean thin brick in accordance with manufacturer's written instructions.
6. Clean masonry with a proprietary acidic cleaner applied according to manufacturer's written instructions.

3.7 MASONRY WASTE DISPOSAL

- A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.
- B. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 04 21 00

SECTION 04 22 00 - CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Concrete masonry units.
2. Mortar and grout.
3. Steel reinforcing bars.
4. Masonry-joint reinforcement.
5. Embedded flashing.
6. Miscellaneous masonry accessories.
7. Masonry-cell fill.

B. Related Requirements:

1. Section 042100 "Unit Masonry – This Brick" for installation of thin brick veneer over concrete masonry units.
2. Section 051200 "Structural Steel Framing" for installing anchor sections of adjustable masonry anchors for connecting to structural steel frame.
3. Section 076200 "Sheet Metal Flashing and Trim" for sheet metal flashing and for furnishing manufactured reglets installed in masonry joints.

1.3 DEFINITIONS

- A. CMU(s): Concrete masonry unit(s).
- B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:

1. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
- C. Shop Drawings: For the following:
1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.
 2. Reinforcing Steel: Detail bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315.
 3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Material Certificates: For each type and size of the following:
1. Masonry units.
 - a. Include material test reports substantiating compliance with performance requirements.
 2. Integral water repellant used in CMUs.
 3. Cementitious materials. Include name of manufacturer, brand name, and type.
 4. Mortar admixtures.
 5. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
 6. Grout mixes. Include description of type and proportions of ingredients.
 7. Reinforcing bars.
 8. Joint reinforcement.
 9. Anchors, ties, and metal accessories.
- C. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.
1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C109/C109M for compressive strength, ASTM C1506 for water retention, and ASTM C91/C91M for air content.
 2. Include test reports, according to ASTM C1019, for grout mixes required to comply with compressive strength requirement.
- D. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined according to TMS 602/ACI 530.1/ASCE 6.
- E. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM C1093 for testing indicated.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Build mockup of typical wall area as shown on Drawings.
 - 2. Build mockups for typical exterior and interior walls in sizes approximately 72 inches (1800 mm) long by 60 inches (1500 mm) high by full thickness, including face and backup wythes and accessories.
 - a. Include a sealant-filled joint at least 16 inches (400 mm) long in each mockup.
 - b. Include through-wall flashing installed for a 24-inch (600-mm) length in corner of exterior wall mockup approximately 16 inches (400 mm) down from top of mockup, with a 12-inch (300-mm) length of flashing left exposed to view (omit masonry above half of flashing).
 - 3. Protect accepted mockups from the elements with weather-resistant membrane.
 - 4. Approval of mockups is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
 - a. Approval of mockups is also for other material and construction qualities specifically approved by Architect in writing.
 - b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Deliver preblended, dry mortar mix in moisture-resistant containers. Store preblended, dry mortar mix in delivery containers on elevated platforms in a dry location or in covered weatherproof dispensing silos.
- E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.9 FIELD CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
 - 1. Extend cover a minimum of 24 inches (600 mm) down both sides of walls, and hold cover securely in place.
- B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least three days after building masonry walls or columns.
- C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
 - 1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
 - 2. Protect sills, ledges, and projections from mortar droppings.
 - 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
 - 4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- D. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
 - 1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F (4 deg C) and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.
- E. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.
- B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.

2.2 PERFORMANCE REQUIREMENTS

- A. Provide unit masonry that develops indicated net-area compressive strengths at 28 days.
 - 1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) according to TMS 602/ACI 530.1/ASCE 6.
 - 2. Determine net-area compressive strength of masonry by testing masonry prisms according to ASTM C1314.

2.3 UNIT MASONRY, GENERAL

- A. Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6 except as modified by requirements in the Contract Documents.
- B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work.

2.4 CONCRETE MASONRY UNITS

- A. Regional Materials: CMUs shall be manufactured within 500 miles (800 km) of Project site from aggregates and cement that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.
- B. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.
 - 1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
 - 2. Provide square-edged units for outside corners unless otherwise indicated.
- C. Integral Water Repellent: Provide units made with integral water repellent for exposed units.
 - 1. Integral Water Repellent: Liquid polymeric, integral water-repellent admixture that does not reduce flexural bond strength. Units made with integral water repellent, when tested according to ASTM E514/E514M as a wall assembly made with mortar containing integral water-repellent manufacturer's mortar additive, with test period extended to 24 hours, shall show no visible water or leaks on the back of test specimen.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) BASF Corporation.
 - 2) Euclid Chemical Company (The); an RPM company.
 - 3) GCP Applied Technologies Inc.
- D. CMUs: ASTM C90.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2150 psi (14.8 MPa).
2. Density Classification: Normal weight unless otherwise indicated.
3. Size (Width): Manufactured to dimensions 3/8 inch (10 mm) less-than-nominal dimensions.
4. Exposed Faces: Provide color and texture matching the range represented by Architect's sample.

2.5 CONCRETE AND MASONRY LINTELS

- A. General: Provide one of the following:
- B. Concrete Lintels: ASTM C1623, matching CMUs in color, texture, and density classification; and with reinforcing bars indicated. Provide lintels with net-area compressive strength not less than that of CMUs.
- C. Concrete Lintels: Precast or formed-in-place concrete lintels complying with requirements in Section 032000 "Concrete Reinforcing," and with reinforcing bars indicated.
- D. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs matching adjacent CMUs in color, texture, and density classification, with reinforcing bars placed as indicated and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.

2.6 MORTAR AND GROUT MATERIALS

- A. Regional Materials: Aggregate for mortar and grout, cement, and lime shall be manufactured within 500 miles (800 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.
- B. Portland Cement: ASTM C150/C150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.
 1. Alkali content shall not be more than 0.1 percent when tested according to ASTM C114.
- C. Hydrated Lime: ASTM C207, Type S.
- D. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.
- E. Masonry Cement: ASTM C91/C91M.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Essroc.
 - b. Lafarge North America Inc.
 - c. Lehigh Hanson; HeidelbergCement Group.

- F. Mortar Cement: ASTM C1329/C1329M.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Lafarge North America Inc.
- G. Aggregate for Mortar: ASTM C144.
1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
 2. For joints less than 1/4 inch (6 mm) thick, use aggregate graded with 100 percent passing the No. 16 (1.18-mm) sieve.
- H. Aggregate for Grout: ASTM C404.
- I. Epoxy Pointing Mortar: ASTM C395, epoxy-resin-based material formulated for use as pointing mortar for glazed or pre-faced masonry units (and approved for such use by manufacturer of units); in color indicated or, if not otherwise indicated, as selected by Architect from manufacturer's colors.
- J. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C494/C494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. BASF Corporation.
 - b. Euclid Chemical Company (The); an RPM company.
 - c. GCP Applied Technologies Inc.
- K. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with CMUs containing integral water repellent from same manufacturer.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. BASF Corporation.
 - b. Euclid Chemical Company (The); an RPM company.
 - c. GCP Applied Technologies Inc.
- L. Water: Potable.

2.7 REINFORCEMENT

- A. Uncoated Steel Reinforcing Bars: ASTM A615/A615M or ASTM A996/A996M, Grade 60 (Grade 420).

- B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch (3.77-mm) steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Heckmann Building Products, Inc.
 - b. Lock Rite.
 - c. Wire-Bond.
- C. Masonry-Joint Reinforcement, General: Ladder type complying with ASTM A951/A951M.
 - 1. Interior Walls: Hot-dip galvanized carbon steel.
 - 2. Exterior Walls: Hot-dip galvanized carbon steel.
 - 3. Wire Size for Side Rods: 0.148-inch (3.77-mm) diameter.
 - 4. Wire Size for Cross Rods: 0.148-inch (3.77-mm) diameter.
 - 5. Spacing of Cross Rods: Not more than 16 inches (407 mm) o.c.
 - 6. Provide in lengths of not less than 10 feet (3 m), with prefabricated corner and tee units.

2.8 TIES AND ANCHORS

- A. General: Ties and anchors shall extend at least 1-1/2 inches (38 mm) into masonry but with at least a 5/8-inch (16-mm) cover on outside face.
- B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:
 - 1. Mill-Galvanized, Carbon-Steel Wire: ASTM A82/A82M, with ASTM A641/A641M, Class 1 coating.
 - 2. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A82/A82M, with ASTM A153/A153M, Class B-2 coating.
 - 3. Stainless Steel Wire: ASTM A580/A580M, Type 304.
 - 4. Galvanized-Steel Sheet: ASTM A653/A653M, Commercial Steel, G60 (Z180) zinc coating.
 - 5. Steel Sheet, Galvanized after Fabrication: ASTM A1008/A1008M, Commercial Steel, with ASTM A153/A153M, Class B coating.
 - 6. Stainless Steel Sheet: ASTM A240/A240M or ASTM A666, Type 304.
 - 7. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Adjustable Anchors for Connecting to Structural Steel Framing: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.
 - 1. Anchor Section for Welding to Steel Frame: Crimped 1/4-inch- (6.35-mm-) diameter, hot-dip galvanized steel wire.
 - 2. Tie Section: Triangular-shaped wire tie made from 0.187-inch- (4.76-mm-) diameter, hot-dip galvanized steel wire.

- D. Partition Top Anchors: 0.105-inch- (2.66-mm-) thick metal plate with a 3/8-inch- (9.5-mm-) diameter metal rod 6 inches (152 mm) long welded to plate and with closed-end plastic tube fitted over rod that allows rod to move in and out of tube. Fabricate from steel, hot-dip galvanized after fabrication.
- E. Rigid Anchors: Fabricate from steel bars 1-1/2 inches (38 mm) wide by 1/4 inch (6.35 mm) thick by 24 inches (610 mm) long, with ends turned up 2 inches (51 mm) or with cross pins unless otherwise indicated
 - 1. Corrosion Protection: Hot-dip galvanized to comply with ASTM A153/A153M.

2.9 EMBEDDED FLASHING MATERIALS

- A. Metal Flashing: Provide metal flashing complying with SMACNA's "Architectural Sheet Metal Manual" and as follows:
 - 1. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.016 inch (0.40 mm) thick.
 - 2. Fabricate continuous flashings in sections 96 inches (2400 mm) long minimum, but not exceeding 12 feet (3.7 m). Provide splice plates at joints of formed, smooth metal flashing.
 - 3. Fabricate through-wall metal flashing embedded in masonry from stainless steel, with ribs at 3-inch (76-mm) intervals along length of flashing to provide an integral mortar bond.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Cheney Flashing Company.
 - 2) Hohmann & Barnard, Inc.
 - 3) Keystone Flashing Company, Inc.
 - 4. Fabricate through-wall flashing with snaplock receiver on exterior face where indicated to receive counterflashing.
 - 5. Fabricate through-wall flashing with drip edge unless otherwise indicated. Fabricate by extending flashing 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees.
 - 6. Fabricate through-wall flashing with sealant stop unless otherwise indicated. Fabricate by bending metal back on itself 3/4 inch (19 mm) at exterior face of wall and down into joint 1/4 inch (6 mm) to form a stop for retaining sealant backer rod.
 - 7. Fabricate metal drip edges and sealant stops for ribbed metal flashing from plain metal flashing of same metal as ribbed flashing and extending at least 3 inches (76 mm) into wall with hemmed inner edge to receive ribbed flashing and form a hooked seam. Form hem on upper surface of metal so that completed seam sheds water.
 - 8. Fabricate metal drip edges from stainless steel. Extend at least 3 inches (76 mm) into wall and 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.
 - 9. Fabricate metal sealant stops from stainless steel. Extend at least 3 inches (76 mm) into wall and out to exterior face of wall. At exterior face of wall, bend metal back on itself for 3/4 inch (19 mm) and down into joint 1/4 inch (6 mm) to form a stop for retaining sealant backer rod.
 - 10. Fabricate metal expansion-joint strips from stainless steel to shapes indicated.
 - 11. Solder metal items at corners.

- B. Flexible Flashing: Use the following unless otherwise indicated:
1. Butyl Rubber Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.040 inch (1.02 mm).
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) DuPont Safety and Construction.
 - 2) GCP Applied Technologies Inc.
 - 3) Raven Industries, Inc.
 - b. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.
- C. Application: Unless otherwise indicated, use the following:
1. Where flashing is indicated to receive counterflashing, use metal flashing.
 2. Where flashing is indicated to be turned down at or beyond the wall face, use metal flashing.
 3. Where flashing is partly exposed and is indicated to terminate at the wall face, use metal flashing with a drip edge.
 4. Where flashing is fully concealed, use metal flashing or flexible flashing.
- D. Solder and Sealants for Sheet Metal Flashings: As specified in Section 076200 "Sheet Metal Flashing and Trim."
- E. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

2.10 MISCELLANEOUS MASONRY ACCESSORIES

- A. Compressible Filler: Premolded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from urethane or PVC.
- B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.
- C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D226/D226M, Type I (No. 15 asphalt felt).

2.11 MASONRY-CELL FILL

- A. Lightweight-Aggregate Fill: ASTM C331/C331M.

2.12 MORTAR AND GROUT MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
 - 1. Do not use calcium chloride in mortar or grout.
 - 2. Use portland cement-lime mortar unless otherwise indicated.
 - 3. For exterior masonry, use portland cement-lime mortar.
 - 4. For reinforced masonry, use portland cement-lime mortar.
 - 5. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.
- B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
- C. Mortar for Unit Masonry: Comply with ASTM C270, Property Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.
 - 1. For reinforced masonry, use Type S.
 - 2. For exterior, above-grade, load-bearing and nonload-bearing walls and parapet walls; for interior load-bearing walls; for interior nonload-bearing partitions; and for other applications where another type is not indicated, use Type N.
 - 3. For interior nonload-bearing partitions, Type O may be used instead of Type N.
- D. Grout for Unit Masonry: Comply with ASTM C476.
 - 1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602/ACI 530.1/ASCE 6 for dimensions of grout spaces and pour height.
 - 2. Proportion grout in accordance with ASTM C476, but not less than 2000 psi (14 MPa)].
 - 3. Provide grout with a slump of 8 to 11 inches (200 to 280 mm) as measured according to ASTM C143/C143M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
 - 2. Verify that foundations are within tolerances specified.
 - 3. Verify that reinforcing dowels are properly placed.
 - 4. Verify that substrates are free of substances that would impair mortar bond.

- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Build chases and recesses to accommodate items specified in this and other Sections.
- B. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.
- C. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

3.3 TOLERANCES

- A. Dimensions and Locations of Elements:
 - 1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch (12 mm) or minus 1/4 inch (6 mm).
 - 2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch (12 mm).
 - 3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch (6 mm) in a story height or 1/2 inch (12 mm) total.
- B. Lines and Levels:
 - 1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
 - 2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 3. For vertical lines and surfaces do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
 - 7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch (1.5 mm).
- C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm), with a maximum thickness limited to 1/2 inch (12 mm).
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3 mm).
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (9 mm) or minus 1/4 inch (6 mm).
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm).

3.4 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.
- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.
- C. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than 4 inches (100 mm). Bond and interlock each course of each wythe at corners. Do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.
- D. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- E. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- F. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.
- G. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below, and rod mortar or grout into core.
- H. Fill cores in hollow CMUs with grout 24 inches (600 mm) under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.
- I. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.
 1. Install compressible filler in joint between top of partition and underside of structure above.
 2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors and push tubes down into grout to provide 1/2-inch (13-mm) clearance between end of anchor rod and end of tube. Space anchors 48 inches (1200 mm) o.c. unless otherwise indicated.

3. Wedge nonload-bearing partitions against structure above with small pieces of tile, slate, or metal. Fill joint with mortar after dead-load deflection of structure above approaches final position.

3.5 MORTAR BEDDING AND JOINTING

- A. Lay hollow CMUs as follows:
 1. Bed face shells in mortar and make head joints of depth equal to bed joints.
 2. Bed webs in mortar in all courses of piers, columns, and pilasters.
 3. Bed webs in mortar in grouted masonry, including starting course on footings.
 4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.
- B. Lay solid CMUs with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.
- C. Rake out mortar joints at pre-faced CMUs to a uniform depth of 1/4 inch (6 mm) and point with epoxy mortar to comply with epoxy-mortar manufacturer's written instructions.
- D. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.
- E. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.
- F. Cut joints flush where indicated to receive waterproofing unless otherwise indicated.

3.6 MASONRY-CELL FILL

- A. Pour lightweight-aggregate fill into cavities to fill void spaces. Maintain inspection ports to show presence of fill at extremities of each pour area. Close the ports after filling has been confirmed. Limit the fall of fill to one story high, but not more than 20 feet (6 m).

3.7 MASONRY-JOINT REINFORCEMENT

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (150 mm).
 1. Space reinforcement not more than 16 inches (406 mm) o.c.
 2. Space reinforcement not more than 8 inches (203 mm) o.c. in foundation walls and parapet walls.
 3. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings in addition to continuous reinforcement.
- B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.

- C. Provide continuity at wall intersections by using prefabricated T-shaped units.
- D. Provide continuity at corners by using prefabricated L-shaped units.
- E. Cut and bend reinforcing units as directed by manufacturer for continuity at returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

3.8 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

- A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:
 - 1. Provide an open space not less than 2 inches (50 mm) wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
 - 2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
 - 3. Space anchors as indicated, but not more than 24 inches (610 mm) o.c. vertically and 36 inches (915 mm) o.c. horizontally.

3.9 CONTROL AND EXPANSION JOINTS

- A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.
- B. Form control joints in concrete masonry as follows:
 - 1. Fit bond-breaker strips into hollow contour in ends of CMUs on one side of control joint. Fill resultant core with grout, and rake out joints in exposed faces for application of sealant.
 - 2. Install preformed control-joint gaskets designed to fit standard sash block.
 - 3. Install interlocking units designed for control joints. Install bond-breaker strips at joint. Keep head joints free and clear of mortar, or rake out joint for application of sealant.
 - 4. Install temporary foam-plastic filler in head joints, and remove filler when unit masonry is complete for application of sealant.

3.10 LINTELS

- A. Provide concrete or masonry lintels where shown and where openings of more than 12 inches (305 mm) for brick-size units and 24 inches (610 mm) for block-size units are shown without structural steel or other supporting lintels.
- B. Provide minimum bearing of 8 inches (200 mm) at each jamb unless otherwise indicated.

3.11 FLASHING

- A. General: Install embedded flashing at ledges and other obstructions to downward flow of water in wall where indicated.

- B. Install flashing as follows unless otherwise indicated:
1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.
 2. At lintels, extend flashing a minimum of 6 inches (150 mm) into masonry at each end. At heads and sills, extend flashing 6 inches (150 mm) at ends and turn up not less than 2 inches (50 mm) to form end dams.
 3. Interlock end joints of ribbed sheet metal flashing by overlapping ribs not less than 1-1/2 inches (38 mm) or as recommended by flashing manufacturer, and seal lap with elastomeric sealant complying with requirements in Section 079200 "Joint Sealants" for application indicated.
 4. Install metal drip edges and sealant stops with ribbed sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 079200 "Joint Sealants" for application indicated.
 5. Install metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal drip edge.
 6. Install metal flashing termination beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal flashing termination.
 7. Cut flexible flashing off flush with face of wall after masonry wall construction is completed.
- C. Install reglets and nailers for flashing and other related construction where they are shown to be built into masonry.

3.12 REINFORCED UNIT MASONRY

- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.
- B. Placing Reinforcement: Comply with requirements in TMS 602/ACI 530.1/ASCE 6.
- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
1. Comply with requirements in TMS 602/ACI 530.1/ASCE 6 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
 2. Limit height of vertical grout pours to not more than 60 inches (1520 mm).

3.13 FIELD QUALITY CONTROL

- A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.
- B. Inspections: Special inspections according to Level B in TMS 402/ACI 530/ASCE 5.
 - 1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.
 - 2. Place grout only after inspectors have verified compliance of grout spaces and of grades, sizes, and locations of reinforcement.
 - 3. Place grout only after inspectors have verified proportions of site-prepared grout.
- C. Testing Prior to Construction: One set of tests.
- D. Testing Frequency: One set of tests for each 5000 sq. ft. (464 sq. m) of wall area or portion thereof.
- E. Concrete Masonry Unit Test: For each type of unit provided, according to ASTM C140 for compressive strength.
- F. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, according to ASTM C780.
- G. Mortar Test (Property Specification): For each mix provided, according to ASTM C780. Test mortar for mortar air content and compressive strength.
- H. Grout Test (Compressive Strength): For each mix provided, according to ASTM C1019.
- I. Prism Test: For each type of construction provided, according to ASTM C1314 at 7 days and at 28 days.

3.14 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:

1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
3. Protect adjacent stone and nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
5. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.

3.15 MASONRY WASTE DISPOSAL

- A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.
- B. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.
 1. Crush masonry waste to less than 4 inches (100 mm) in each dimension.
 2. Mix masonry waste with at least two parts of specified fill material for each part of masonry waste. Fill material is specified in Section 312000 "Earth Moving."
 3. Do not dispose of masonry waste as fill within 18 inches (450 mm) of finished grade.
- C. Masonry Waste Recycling: Return broken CMUs not used as fill to manufacturer for recycling.
- D. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

END OF SECTION 04 22 00

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SECTION 04 43 15 - GRANITE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Granite for use in the following applications:
 - a. Paving and granite aprons.
 - b. Granite thresholds.
 - c. Accent pavers/tiles.
- B. Related Requirements:
 - 1. Section 03 30 00 "Cast-In-Place Concrete."
 - 2. Section 04 05 13 "Mortar, Grout and Masonry Accessories."
 - 3. Section 05 12 00 "Structural Steel Framing."
 - 4. Section 05 50 00 "Metal Fabrications."
 - 5. Section 07 92 00 "Joint Sealants."

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's technical data, catalog cuts, installation and maintenance instructions for all granite types required.
- B. Shop Drawings:
 - 1. Indicate bedding, bonding and jointing of granite, including typical and special anchoring, expansion-joint details and interface with other work.
 - 2. Indicate dimensions and setting numbers of each stone in plan and elevation, including grading data for drainage.
- C. Working Drawings:
 - 1. Include full explanation of erection methods and installation procedures, temporary loading, anchor design, surface preparation, setting materials, bonding, testing and other work as directed.
 - 2. For granite walls, include structural analysis data signed and sealed by the qualified professional structural engineer responsible for their preparation.

D. Samples for Verification:

1. Stone Samples: Submit three sets of samples of each type of granite used in the work, showing full range of color, texture, veining, fissures and finish of each type; each sample 12 inches square by one-inch thick.
 - a. Include a minimum of two pieces in each set with maximum number of pieces in each set as necessary to demonstrate full range and variations.
 - b. Material delivered or erected not within approved range samples will be rejected.
2. Epoxy for Mortar Dams and Epoxy Fill and for Setting Dowels: Manufacturer's standard container.
3. Non-staining Wedge. Stainless steel dowel.
4. Platform Edge Glass Lens and Sealant: Section 08 80 00.
 - a. Cured six-inch long strip of grout matching existing white granite grout joint color for granite slab transverse joint grouting: Section 04 05 13.
 - b. Platform Joint Sealant: Section 07 92 00.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

1. Quality-Assurance Program.

F. Material Certificates: For each type and size of the following:

1. Granite: For each type of granite and application, include data on material properties and material test reports substantiating compliance with requirements.

G. Material Test Reports:

1. Stone Test Reports: For each stone variety proposed for use on Project, by a qualified testing agency, indicating compliance with required physical properties, other than abrasion resistance, according to referenced ASTM standards. Base reports on testing done within the previous three years.
2. For metal components, by a qualified testing agency, indicating chemical and physical properties of metal.
3. Sealant Compatibility and Adhesion Test Report: From sealant manufacturer complying with requirements in Section 07 92 00 "Joint Sealants" and indicating that sealants will not stain or damage stone. Include interpretation of test results and recommendations for primers and substrate preparation needed for adhesion.

H. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.04 QUALITY ASSURANCE

A. Reference Standards and Specifications. Provide granite in compliance with the following industry standards and as specified.

1. ASTM International (ASTM):
 - a. ASTM C97, "Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone."

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- b. ASTM C99, "Standard Test Method for Modulus of Rupture of Dimension Stone."
 - c. ASTM C170, "Standard Test Method for Compressive Strength of Dimension Stone."
 - d. ASTM C241, "Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic."
 - e. ASTM C615, "Standard Specification for Granite Dimension Stone."
 - f. ASTM C880, "Standard Test Method for Flexural Strength of Dimension Stone."
 - g. ASTM C1028, "Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method."
 - h. ASTM C1242, "Standard Guide for Selection, Design, and Installation of Dimension Stone Attachment Systems."
2. ICC A117.1-2009 Accessible and Usage Buildings and Facilities.
 3. National Building Granite Quarries Association (NBGQA): Specifications for Architectural Granite.
- B. Source Limitations:
1. Obtain each variety of stone, regardless of finish, from a single quarry with resources to provide materials of consistent quality in appearance and physical properties.
- C. Qualifications of Granite Quarries:
1. Quarry shall be a member company of the National Building Granite Quarries Association (NBGQA).
 2. Obtain granite from quarries having capacity and facilities for furnishing the quantity, size and quality of granite required.
- D. Installer Qualifications: An experienced installer who has completed dimension stone assemblies similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- E. Visual Matching:
1. Provide the product of one quarry matching approved samples.
 2. Where specifications require matching an established or specified item, the Authority's decision will be final on whether a proposed product matches satisfactorily.
 3. Where no product is available that adequately matches adjacent products or complies with the other specified requirements, comply with provisions of 01 33 00, Substitution Procedures, for selection of an alternate product.
- F. Mock-Ups: Before installing granite, construct mockup to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials specified and indicated for completed work.
1. Granite Curbs:
 - a. Build mockups of typical exterior wall with dimension stone cladding, approximately 72 inches long by 48 inches high or as directed by the Engineer.
 - b. Show typical components, attachments to building structure, and methods of installation. Include sealant-filled joint complying with requirements in Section 07 92 00.

2. Acceptance of mockups is for color, texture, pattern and blending; relationship of mortar and sealant colors to granite colors; tooling of joints; and aesthetic qualities of workmanship.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Pack granite so as to prevent damage in transit, and deliver in accordance with Contract schedule and setting sequence.
- B. Deliver each piece of granite with code mark on unexposed face, corresponding to shop drawings using nonstaining paint. Deliver and unload granite. Prevent damage and soiling during delivery and unloading of granite.
- C. Protect from disfiguring elements.
- D. Separate granite from wood skids with polyethylene or other nonstaining material. Store under waterproof covering, and keep dry.
- E. Remove rejected granite from jobsite immediately.

1.06 FIELD CONDITIONS

- A. Environmental Requirements:
 1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit repointing work to be performed according to product manufacturers' written instructions and specified requirements.
 2. Do not use frozen materials or materials mixed or coated with ice or frost. Remove and replace dimension stone damaged by frost or freezing conditions.
 3. Erection and pointing of granite when ambient temperature is below 50 Deg F and or tending to fall below 50 Deg F is prohibited.
- B. Cold-Weather Requirements:
 1. Protection:
 - a. When night-time temperature is forecasted within 50 to 25 Deg F, cover dimension stone with a weather-resistant membrane for 48 hours after construction.
 - b. Do not install granite when night time temperature is forecasted below 25 Deg F.
- C. Hot-Weather Requirements:
 1. Protect mortar-joint pointing when temperature and humidity conditions produce excessive evaporation of water from mortar materials.
 2. Provide artificial shade and wind breaks, and use cooled materials as required to minimize evaporation.
 3. Do not apply mortar to substrates with temperatures of 90 deg F and above unless otherwise indicated.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Division 01, "General Requirements," to design dimension stone granite stone assemblies for the indicated and specified application.
- B. Static Coefficient of Friction: ASTM C1028, ANSI A137.1, values as follows:
 - 1. Level Surfaces: A minimum of 0.6.
 - 2. Ramp Surfaces: A minimum of 0.8.
- C. General: Design stone anchors and anchoring systems according to ASTM C1242, "Standard Guide for Selection, Design, and Installation of Dimension Stone Attachment Systems."
 - 1. Stone anchors shall withstand not less than two times the weight of the stone cladding in both compression and tension.
- D. Structural Performance: Dimension stone assemblies shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Snow Loads: As indicated on the Drawings.
 - 2. Live Loads: As indicated on the Drawings.
 - 3. Equipment Loads: Allow for loads due to window cleaning and maintenance equipment.
- E. Seismic Performance: Dimension stone assemblies shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. Component Importance Factor: 1.5.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.
- G. Safety Factors for Stone: Design dimension stone assemblies to withstand loads indicated without exceeding stone's allowable working stress determined by dividing stone's average ultimate strength, as established by testing, by the following safety factors:
 - 1. Safety Factor for Granite: 3.
 - 2. Safety Factor for Concentrated Stresses: 4 for granite.
- H. Provisions for Fabrication and Erection Tolerances:
 - 1. Allow for fabrication and erection tolerances of building's structural system. Concrete fabrication and erection tolerances are specified in Section 03 30 00, "Cast-in-Place Concrete." Structural-steel fabrication and erection tolerances are specified in Section 05 12 00, "Structural Steel Framing."
- I. Corrosion and Staining Control: Prevent galvanic and other forms of corrosion as well as staining by isolating metals and other materials from direct contact with incompatible materials. Materials shall not stain exposed surfaces of stone and joint materials.

- J. Contrast Between Granite and Adjacent Floor Surfaces: Light reflectance contrast of specified granite shall measure 75% higher than adjacent floor material as tested by ASTM C609, "Standard Test Method for Measurement of Light Reflectance Value and Small Color Differences Between Pieces of Ceramic Tile".

2.02 MATERIALS

A. Granite:

1. Material Standards:
 - a. ASTM C615, "Standard Specification for Granite Dimension Stone."
 - b. NBGQA "Specifications for Architectural Granite".
2. Basis of Design Fabricator and Quarry: North Carolina Granite Corporation, Mount Airy, North Carolina, is specified to establish required level of quality, appearance, and performance.
 - a. Comparable granite from other quarries meeting the specified requirements will be considered for approval as a request for substitution under the provisions of Division 01.
3. Basis of Design Product: "Georgia Grey Granite".
 - a. Physical Characteristics:

Properties	Basis of Design - "Mt Airy Granite" Data (English units)	ASTM Test Method(s)
Absorption by Weight (%)	0.26	C97
Density, lbs/ft ³ , (kg/m ³)	165.12	C97
Compressive strength, psi, (MPa)	19,774	C170
Modules of rupture, Min psi	2,650	C99
Abrasion resistance, min. ⁴	25	C241/C1353
Flexural strength, psi, (MPa)	1,724	C880

(⁴ Pertains only to stone subject to foot traffic)

4. Color Classification: Gray, granite matching grain, color and variegation of all gray, medium-grain granite as listed in referenced NBGQA standard.
5. Color, Texture, Veining, Fissures and Pattern: Match Architect's samples located at the Authority's headquarters office.
6. Finishes: Exposed surfaces finished in accordance with the following and as shown:
 - a. Type 1: Thermal finish.
7. Where stone thickness permits, provide lewis holes for lifting stones weighing over 100 pounds. Make lewis holes not closer than two inches from finished face of stone nor in exposed portions of stone.
8. For alteration and restoration work, use granite salvaged from existing work. If salvaged granite is not sufficient, provide new granite to match existing granite in type, size and appearance.

B. Mortar Materials and Granite Accessories: Section 04 05 13.

C. Portland Cement Paste: Section 03 30 00.

- D. Granite Sealer: Silicone-based repellent-treatment and sealer. Verify that product does not discolor granite and exhibits sufficient repellent characteristics.
 - 1. Acceptable Manufacturers and Products:
 - a. Prosoco SLX100 StandOff.
 - b. HMK StoneCare.
 - c. Miracle Sealants 511 Porous Plus.
 - d. Or approved equal.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surfaces to receive dimension stone assemblies and conditions under which dimension stone will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of dimension stone assemblies.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Runways, Scaffolds and Hoists: Provide and move scaffolding, temporary runways, temporary floors, staging and hoists in accordance with specified safety requirements.
- B. Substrate: Remove foreign substances that would affect bond of mortar from surfaces to receive granite.
- C. Advise installers of other work about specific requirements for placement of inserts, flashing reglets, and similar items to be used by dimension stone Installer for anchoring, supporting, and flashing of dimension stone assemblies. Furnish installers of other work with Drawings or templates showing locations of these items.

3.03 FABRICATION AND ERECTION

- A. General:
 - 1. Fabricate granite in sizes and with joint patterns shown on Contract Drawings and approved shop drawings.
 - 2. Installation of granite which is not within the approved range of color, texture, finish, veining and fissures, is mismatched, shows flaws or imperfection in cutting, or has other defects, is prohibited.
 - 3. Provide openings for installation of work of other trades in accordance with approved shop drawings. Coordinate size of rabbet at expansion joint in granite platform edging with the expansion joint dimension and the size of compression seal.
 - 4. Provide 1/4-inch joints, unless otherwise shown on Contract Drawings and approved shop drawings.

5. Unless otherwise shown, completely fill joints in granite work and rake out to depth of 3/4 inch, except paving joints and pylon-apron joints showing grout.
6. Set stones accurately in alignment with other stones and adjacent work. Set stones in full mortar beds. Level and plumb stones as work progresses.
7. Set finish surfaces in true and even planes, with uniform jointing. Take up and reset loose, hollow sounding slabs. Leave surface free of mortar stain and other defacements.
8. Where epoxy materials are used, follow manufacturer's recommendations.

B. Tolerances: Meet NBGQA Specifications for Architectural Granite.

C. Granite Sets:

1. As shown on the Drawings.

3.04 POINTING AND CLEANING

A. Pointing:

1. After setting mortar has cured, point voids in joints of exposed granite paving and pylon aprons with preshrunk mortar. Remove excess mortar.
2. Seal joints in granite work with sealants in accordance with Section 07 92 00, except paving joints and pylon-apron joints.

B. Cleaning:

1. Clean joint surfaces and remove dirt, coatings, moisture and other foreign substances which could interfere with bond. Recaulk granite edge slabs' transverse joints both vertically and horizontally with grout and let cure.
2. Thoroughly and carefully clean work by approved means and leave in first class condition, free from mortar or other defacement. Clean all exposed granite surfaces, including joints, with water and washing compound soap powder solution in accordance with recommendations of manufacturer. Sponge and wash thoroughly. Use of acid or acid cleaners is prohibited. Remove stains by approved means. Clean granite masonry surfaces, including those grouted or sealed, with soap-powder solution and fiber brushes to remove stains. Thoroughly and carefully clean work and leave in first-class condition, free from mortar stains or other defacement. Immediately after cleaning, rinse surfaces with clear water. Polish with clean dry cloths.

3.05 PROTECTION

- A. Protect granite work from damage after erection. Provide protective boxing or other suitable means whenever necessary in the absence of specific instructions from the Engineer. Do not use materials that will stain or deface granite. Use galvanized nails in protective boxing.
- B. Continuously protect granite work from water during construction and until installation is complete and is approved.
- C. Protect granite work from traffic of any kind for not less than two hours after setting. Remove protection immediately after two hours curing.
- D. Treat Granite surfaces with silicone-based water and stain repellent, per repellent manufacturer's recommendations.

3.06 FIELD QUALITY ASSURANCE

A. Granite Platform Edging:

1. Perform work in accordance with approved quality-assurance program.
2. Change of procedures and personnel without approval is prohibited.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION

SECTION 051200 - STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

- 1. Structural steel.
- 2. Field-installed shear connectors.
- 3. Grout.

B. Related Requirements:

- 1. Section 053100 "Steel Decking" for field installation of shear connectors through deck.
- 2. Section 055000 "Metal Fabrications" for steel lintels and shelf angles not attached to structural-steel frame, miscellaneous steel fabrications and other steel items not defined as structural steel.
- 3. Section 099100 "Exterior Painting" for surface-preparation and priming requirements.
- 4. Section 099600 "High Performance Coatings" where indicated

1.3 DEFINITIONS

- A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

1.4 COORDINATION

- A. Coordinate requirements for painting and/or galvanizing with the finish schedule(s) provided in the design drawings and the requirements per Section 099100.
- B. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- C. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show fabrication of structural-steel components.
 - 1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
 - 2. Include embedment Drawings.
 - 3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
 - 4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections.
- C. Delegated-Design Submittal: For structural-steel connections indicated to comply with design loads, include analysis data signed and sealed by the qualified professional engineer licensed in the Commonwealth of Virginia and responsible for their preparation.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, fabricator, professional engineer, and testing agency.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
- D. Mill test reports for structural steel, including chemical and physical properties.
- E. Product Test Reports: For the following:
 - 1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
 - 2. Direct-tension indicators.
 - 3. Tension-control, high-strength, bolt-nut-washer assemblies.
 - 4. Shear stud connectors.
 - 5. Shop primers.
 - 6. Nonshrink grout.
- F. Survey of existing conditions.
- G. Source quality-control reports.
- H. Field quality-control and special inspection reports.

1.8 QUALITY ASSURANCE

- A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category CBD and SBD.
- B. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category CSE.
- C. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P3 or to SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."
- D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- E. Comply with applicable provisions of the following specifications and documents:
 - 1. AISC 303.
 - 2. AISC 360.
 - 3. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
 - 1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
- B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
 - 1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
 - 2. Clean and relubricate bolts and nuts that become dry or rusty before use.
 - 3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Connections: Provide details of connections required by the Contract Documents to be selected or completed by structural-steel fabricator, including comprehensive engineering analysis by a qualified professional engineer licensed in the Commonwealth of Virginia, to withstand loads indicated and comply with other information and restrictions indicated.

1. Select and complete connections using schematic details indicated and AISC 360.
 2. Use Load and Resistance Factor Design
- B. Moment Connections: Type FR, fully restrained.
- C. Construction: Moment frame

2.2 STRUCTURAL-STEEL MATERIALS

- A. W-Shapes: ASTM A 992/A 992M.
- B. H-Pile Steel: ASTM A690
- C. Channels, Angles-Shapes: ASTM A 36/A 36M.
- D. Plate and Bar: ASTM A 36/A 36M.
- E. Steel Pipe: ASTM A 53/A 53M, Type E or Type S, Grade B.
1. Weight Class: Standard.
 2. Finish: Galvanized.
- F. Welding Electrodes: Comply with AWS requirements.

2.3 BOLTS, CONNECTORS, AND ANCHORS

- A. High-Strength Bolts, Nuts, and Washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, (ASTM A 563M, Class 8S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers; all with plain finish.
1. Direct-Tension Indicators: ASTM F 959, Type 325 (ASTM F 959M, Type 8.8), compressible-washer type with plain finish where fire proofing is to be applied, otherwise hot-dip zinc coating, ASTM A 153/A 153M, Class C
- B. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.
- C. Headed Anchor Rods: ASTM F 1554, Grade 36, ASTM F 1554, Grade 55, weldable, straight.
1. Nuts: ASTM A 563 (ASTM A 563M) heavy-hex carbon steel.
 2. Plate Washers: ASTM A 36/A 36M carbon steel.
 3. Washers: ASTM F 436 (ASTM F 436M), Type 1, hardened carbon steel.
 4. Finish: Hot-dip zinc coating, ASTM A 153/A 153M, Class C.
- D. Structural Slide Bearings: Low-friction assemblies, of configuration indicated, that provide vertical transfer of loads and allow horizontal movement perpendicular to plane of expansion joint while resisting movement within plane of expansion joint.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. GRM Custom Products.
 - b. R.J. Watson Bridge & Structural Engineered Systems.
2. Mating Surfaces: PTFE and PTFE, or PTFE and mirror-finished stainless steel.
3. Coefficient of Friction: Not more than 0.03
4. Design Load: Not less than 2,000 psi (13.7 MPa)
5. Total Movement Capability: 2 inches (50 mm).

2.4 PRIMER

- A. Primer: Comply with Section 099100 "Exterior Painting." Ensure compatibility with Tenemec epoxy system (Series 113, 114 & 115 Tenemec topcoat)
- B. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20.

2.5 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.6 FABRICATION

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," and to AISC 360.
 1. Camber structural-steel members where indicated.
 2. Fabricate beams with rolling camber up.
 3. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
 4. Mark and match-mark materials for field assembly.
 5. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
- B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
 1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.
- C. Bolt Holes: Cut, drill, or punch standard bolt holes perpendicular to metal surfaces.
- D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
- E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 1, "Solvent Cleaning."

- F. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.
- G. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.
 - 1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
 - 2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
 - 3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.7 SHOP CONNECTIONS

- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 - 1. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

2.8 SHOP PRIMING

- A. Shop prime steel surfaces except the following:
 - 1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches (50 mm).
 - 2. Surfaces to be field welded.
 - 3. Surfaces of high-strength bolted, slip-critical connections.
 - 4. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
 - 5. Galvanized surfaces.
 - 6. Surfaces enclosed in interior construction.
- B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits.
- C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils (0.038 mm). Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
 - 1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
 - 2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

- D. Painting: Prepare steel and apply a one-coat, nonasphaltic primer complying with SSPC-PS Guide 7.00, "Painting System Guide 7.00: Guide for Selecting One-Coat Shop Painting Systems," to provide a dry film thickness of not less than 1.5 mils (0.038 mm).

2.9 GALVANIZING

- A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123/A 123M.
 - 1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
 - 2. Galvanize lintels and shelf angles attached to structural-steel frame and located in exterior walls.

2.10 SOURCE QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform shop tests and inspections.
 - 1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
- B. Bolted Connections: Inspect shop-bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- C. Welded Connections: Visually inspect shop-welded connections according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - 1. Liquid Penetrant Inspection: ASTM E 165.
 - 2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
 - 3. Ultrasonic Inspection: ASTM E 164.
 - 4. Radiographic Inspection: ASTM E 94.
- D. In addition to visual inspection, test and inspect shop-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
 - 1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
 - 2. Conduct tests according to requirements in AWS D1.1/D1.1M on additional shear connectors if weld fracture occurs on shear connectors already tested.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
 - 1. Prepare a certified survey of existing conditions. Include bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.
 - 1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

- A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.
- B. Baseplates, Bearing Plates and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
 - 1. Set plates for structural members on wedges, shims, or setting nuts as required.
 - 2. Weld plate washers to top of baseplate.
 - 3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 - 4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- C. Maintain erection tolerances of structural steel within AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."
- D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that are in

permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.
 2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.
- E. Splice members only where indicated.
- F. Do not use thermal cutting during erection.
- G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
- H. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

3.4 FIELD CONNECTIONS

- A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
 2. Remove backing bars or runoff tabs] back gouge, and grind steel smooth.
 3. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," for mill material.

3.5 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
1. Verify structural-steel materials and inspect steel frame joint details.
 2. Verify weld materials and inspect welds.
 3. Verify connection materials and inspect high-strength bolted connections.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- C. Bolted Connections: Inspect bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- D. Welded Connections: Visually inspect field welds according to AWS D1.1/D1.1M.

1. In addition to visual inspection, test and inspect field welds according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - a. Liquid Penetrant Inspection: ASTM E 165.
 - b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
 - c. Ultrasonic Inspection: ASTM E 164.
 - d. Radiographic Inspection: ASTM E 94.
- E. In addition to visual inspection, test and inspect field-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
 1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
 2. Conduct tests according to requirements in AWS D1.1/D1.1M on additional shear connectors if weld fracture occurs on shear connectors already tested.

3.6 REPAIRS AND PROTECTION

- A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A 780/A 780M.
- B. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning. Retain "Touchup Painting" Paragraph below if touchup painting is required for Project but is not part of the Work of this Section.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 051200

SECTION 053100 - STEEL DECKING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. VDOT Road and Bridge Specifications, 2016

1.2 SUMMARY

A. Section Includes:

- 1. Roof deck.
- 2. Composite floor deck.
- 3. Composite bridge deck
- 4. Non-composite form deck.
- 5. Non-composite vented form deck.

B. Related Requirements:

- 1. Section 033000 "Cast-in-Place Concrete" for normal-weight and lightweight structural concrete fill over steel deck.
- 2. Section 051200 "Structural Steel Framing" for shop- and field-welded shear connectors.
- 3. Section 055000 "Metal Fabrications" for framing deck openings with miscellaneous steel shapes.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of deck, accessory, and product indicated.
- B. Shop Drawings:
 - 1. Include layout and types of deck panels, anchorage details, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Product Certificates: For each type of steel deck.
- C. Product Test Reports: For tests performed by a qualified testing agency, indicating that each of the following complies with requirements:

1. Power-actuated mechanical fasteners.
- D. Evaluation Reports: For steel deck, from ICC-ES.
- E. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.
- B. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. AISI Specifications: Comply with calculated structural characteristics of steel deck according to AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."

2.2 ROOF DECK

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Nucor Corp.; Vulcraft 1.5B
- B. Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with "SDI Specifications and Commentary for Steel Roof Deck," in SDI Publication No. 31, and with the following:
 1. Deck Profile: Type WR, wide rib.
 2. Profile Depth: As indicated.
 3. Design Uncoated-Steel Thickness: As indicated.
 4. Span Condition: As indicated.
 5. Side Laps: Overlapped or interlocking seam at Contractor's option.

2.3 COMPOSITE FLOOR DECK

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Nucor Corp.; Vulcraft 2 VLI
- B. Composite Floor Deck: Fabricate panels, with integrally embossed or raised pattern ribs and interlocking side laps, to comply with "SDI Specifications and Commentary for Composite Steel Floor Deck," in SDI Publication No. 31, with the minimum section properties indicated, and with the following:
 - 1. Galvanized-Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), minimum Grade 50, G90 (Z275) zinc coating.
 - 2. Profile Depth: As indicated.
 - 3. Design Uncoated-Steel Thickness: As indicated.
 - 4. Span Condition: As indicated.

2.4 COMPOSITE BRIDGE DECK

- A. Conform to VDOT Road and Bridge Specifications, Section 404.03.

2.5 NONCOMPOSITE FORM DECK

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Nucor Corp.; Vulcraft 1.5C
- B. Non-composite Form Deck: Fabricate ribbed-steel sheet non-composite form-deck panels to comply with "SDI Specifications and Commentary for Non-composite Steel Form Deck," in SDI Publication No. 31, with the minimum section properties indicated, and with the following:
 - 1. Galvanized Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), minimum Grade 50, G90 (Z275) zinc coating.
 - 2. Profile Depth: As indicated.
 - 3. Design Uncoated-Steel Thickness: As indicated.
 - 4. Span Condition: As indicated.
 - 5. Side Laps: Overlapped or interlocking seam at Contractor's option.

2.6 NONCOMPOSITE VENTED FORM DECK

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Nucor Corp; Vulcraft 1.5BSV

- B. Non-composite Vented Form Deck: Fabricate ribbed- and vented-steel sheet non-composite form-deck panels to comply with "SDI Specifications and Commentary for Non-composite Steel Form Deck," in SDI Publication No. 31, and with the following:
1. Galvanized-Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), minimum Grade 50, G90 (Z275) zinc coating.
 2. Profile Depth: As indicated.
 3. Design Uncoated-Steel Thickness: As indicated.
 4. Span Condition: As indicated.
 5. Side Laps: Overlapped or interlocking seam at Contractor's option.
 6. Vent Slot Area: Manufacturer's standard vent slots providing minimum 0.5percent open area.

2.7 ACCESSORIES

- A. General: Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.
- B. Mechanical Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws.
- C. Side-Lap Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 10 (4.8-mm) minimum diameter.
- D. Flexible Closure Strips: Vulcanized, closed-cell, synthetic rubber.
- E. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi (230 MPa), not less than 0.0359-inch (0.91-mm) design uncoated thickness, of same material and finish as deck; of profile indicated or required for application.
- F. Pour Stops and Girder Fillers: Steel sheet, minimum yield strength of 33,000 psi (230 MPa), of same material and finish as deck, and of thickness and profile recommended by SDI Publication No. 31 for overhang and slab depth.
- G. Column Closures, End Closures, Z-Closures, and Cover Plates: Steel sheet, of same material, finish, and thickness as deck unless otherwise indicated.
- H. Flat Sump Plates: Single-piece steel sheet, 0.0747 inch (1.90 mm) thick, of same material and finish as deck. For drains, cut holes in the field.
- I. Galvanizing Repair Paint: ASTM A 780/A 780M.
- J. Repair Paint: Manufacturer's standard rust-inhibitive primer of same color as primer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine supporting frame and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install deck panels and accessories according to applicable specifications and commentary in SDI Publication No. 31, manufacturer's written instructions, and requirements in this Section.
- B. Install temporary shoring before placing deck panels if required to meet deflection limitations.
- C. Locate deck bundles to prevent overloading of supporting members.
- D. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract side-lap interlocks.
- E. Place deck panels flat and square and fasten to supporting frame without warp or deflection.
- F. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.
- G. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of deck, and support of other work.
- H. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.
- I. Mechanical fasteners may be used in lieu of welding to fasten deck. Locate mechanical fasteners and install according to deck manufacturer's written instructions.

3.3 ROOF-DECK INSTALLATION

- A. Fasten roof-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated or arc seam welds with an equal perimeter that is not less than 1-1/2 inches (38 mm) long, and as follows:
 - 1. Weld Diameter: As indicated.
 - 2. Weld Spacing: Weld edge and interior ribs of deck units with a minimum of two welds per deck unit at each support. Space welds as indicated.

- B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of one-half of the span or 18 inches (457 mm)] , and as follows:
 - 1. Mechanically fasten with self-drilling, No. 10 (4.8-mm-) diameter or larger, carbon-steel screws.
 - 2. Mechanically clinch or button punch.
- C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches (38 mm), with end joints as follows:
 - 1. End Joints: Lapped 2 inches (51 mm) minimum.
- D. Roof Sump Pans and Sump Plates: Install over openings provided in roof deck and mechanically fasten flanges to top of deck. Space mechanical fasteners not more than 12 inches (305 mm) apart with at least one fastener at each corner.
 - 1. Install reinforcing channels or zees in ribs to span between supports and weld or mechanically fasten.
- E. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels according to deck manufacturer's written instructions. Weld or mechanically fasten to substrate to provide a complete deck installation.
 - 1. Weld cover plates at changes in direction of roof-deck panels unless otherwise indicated.
- F. Flexible Closure Strips: Install flexible closure strips over partitions, walls, and where indicated. Install with adhesive according to manufacturer's written instructions to ensure complete closure.

3.4 FLOOR-DECK INSTALLATION

- A. Fasten floor-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated and as follows:
 - 1. Weld Diameter: As indicated.
 - 2. Weld Spacing: Space and locate welds as indicated.
- B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of one-half of the span or 36 inches (914 mm), and as follows:
 - 1. Mechanically fasten with self-drilling, No. 10 (4.8-mm-) diameter or larger, carbon-steel screws.
 - 2. Mechanically clinch or button punch.
- C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches (38 mm), with end joints as follows:
 - 1. End Joints: Lapped.

- D. Pour Stops and Girder Fillers: Weld steel sheet pour stops and girder fillers to supporting structure according to SDI recommendations unless otherwise indicated.
- E. Floor-Deck Closures: Weld steel sheet column closures, cell closures, and Z-closures to deck, according to SDI recommendations, to provide tight-fitting closures at open ends of ribs and sides of deck.

3.5 BRIDGE DECK INSTALLATION

- A. Conform to VDOT Road and Bridge Specifications, Section 404.3

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Field welds will be subject to inspection.
- C. Prepare test and inspection reports.

3.7 PROTECTION

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on both surfaces of deck with galvanized repair paint according to ASTM A 780/A 780M and manufacturer's written instructions.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 053100

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SECTION 054000 - COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Exterior non-load-bearing wall framing.
 - 2. Ceiling joist framing.
 - 3. Soffit framing.
- B. Related Requirements:
 - 1. Section 055000 "Metal Fabrications" for miscellaneous steel shapes, masonry shelf angles, and connections used with cold-formed metal framing.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include layout, spacings, sizes, thicknesses, and types of cold-formed steel framing; fabrication; and fastening and anchorage details, including mechanical fasteners.
 - 2. Indicate reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.
- C. Delegated-Design Submittal: For cold-formed steel framing.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Welding certificates.

- C. Product Certificates: For each type of code-compliance certification for studs and tracks.
- D. Product Test Reports: For each listed product, for tests performed by a qualified testing agency.
 - 1. Steel sheet.
 - 2. Expansion anchors.
 - 3. Power-actuated anchors.
 - 4. Mechanical fasteners.
 - 5. Vertical deflection clips.
 - 6. Horizontal drift deflection clips
 - 7. Miscellaneous structural clips and accessories.
- E. Evaluation Reports: For nonstandard cold-formed steel framing post-installed anchors and power-actuated fasteners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
- B. Product Tests: Mill certificates or data from a qualified independent testing agency indicating steel sheet complies with requirements, including base-metal thickness, yield strength, tensile strength, total elongation, chemical requirements, and metallic-coating thickness.
- C. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Steel Framing Industry Association.
- D. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AllSteel & Gypsum Products, Inc.
 - 2. CEMCO; California Expanded Metal Products Co.
 - 3. ClarkDietrich Building Systems.
 - 4. Nuconsteel, A Nucor Company.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, licensed in the Commonwealth of Virginia, to design cold-formed steel framing.
- B. Structural Performance: Provide cold-formed steel framing capable of withstanding design loads within limits and under conditions indicated.
 - 1. Design Loads: As indicated on Drawings.
 - 2. Deflection Limits: Design framing systems to withstand design loads without deflections greater than the following:
 - a. Exterior Non-Load-Bearing Framing: Horizontal deflection of 1/600 of the wall height.
 - b. Ceiling Joist Framing: Vertical deflection of 1/360 of the span for live loads and 1/240 for total loads of the span.
 - 3. Design framing systems to provide for movement of framing members located outside the insulated building envelope without damage or overstressing, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change of 120 deg F (67 deg C).
 - 4. Design framing system to maintain clearances at openings, to allow for construction tolerances, and to accommodate live load deflection of primary building structure as follows:
 - 5. Design exterior non-load-bearing wall framing to accommodate horizontal deflection without regard for contribution of sheathing materials.
- C. Cold-Formed Steel Framing Standards: Unless more stringent requirements are indicated, framing shall comply with AISI S100, AISI S200, and the following:
 - 1. Wall Studs: AISI S211.
 - 2. Headers: AISI S212.
 - 3. Lateral Design: AISI S213.
- D. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency acceptable to authorities having jurisdiction.

2.3 COLD-FORMED STEEL FRAMING MATERIALS

- A. Steel Sheet: ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of grade and coating designation as follows:
 - 1. Grade: As indicated.
 - 2. Coating: G90 (Z275)
 - 3. Painted finish over galvanizing: Where indicated on design drawings.

2.4 EXTERIOR NON-LOAD-BEARING WALL FRAMING

- A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
 - 1. Minimum Base-Metal Thickness: 0.0538 inch (1.37 mm).
 - 2. Flange Width: 1-5/8 inches (41 mm).
- B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with unstiffened flanges, and as follows:
 - 1. Minimum Base-Metal Thickness: Matching steel studs.
 - 2. Minimum Flange Width: 1-1/4 inches (32 mm).
- C. Double Deflection Tracks: Manufacturer's double, deep-leg, U-shaped steel tracks, consisting of nested inner and outer tracks; unpunched, with unstiffened flanges.
 - 1. Outer Track: Of web depth to allow free vertical movement of inner track, with flanges designed to support horizontal loads and transfer them to the primary structure, and as follows:
 - a. Minimum Base-Metal Thickness: 0.0538 inch (1.37 mm).
 - b. Flange Width: 1 inch (25 mm) plus the design gap for one-story structures and 1 inch (25 mm) plus twice the design gap for other applications.
 - 2. Inner Track: Of web depth indicated, and as follows:
 - a. Minimum Base-Metal Thickness: 0.0428 inch (1.09 mm).
 - b. Flange Width: outer deflection track flange width plus 1 inch (25 mm).

2.5 SOFFIT FRAMING

- A. Exterior Soffit Frame: Manufacturer's standard C-shaped steel sections, of web depths indicated, with stiffened flanges, and as follows:
 - 1. Minimum Base-Metal Thickness: 0.0428 inch (1.09 mm).
 - 2. Flange Width: 1-5/8 inches (41 mm) >, minimum.

2.6 FRAMING ACCESSORIES

- A. Fabricate steel-framing accessories from ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated steel sheet, of same grade and coating designation used for framing members.
- B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:
 - 1. Supplementary framing.
 - 2. Bracing, bridging, and solid blocking.
 - 3. Web stiffeners.

4. Anchor clips.
5. End clips.
6. Foundation clips.
7. Joist hangers and end closures.
8. Hole-reinforcing plates.
9. Backer plates.

2.7 ANCHORS, CLIPS, AND FASTENERS

1. Type: Torque-controlled expansion anchor or Torque-controlled adhesive anchor.
 2. Material for Exterior or Interior Locations and Where Stainless Steel Is Indicated: Alloy Group 2 stainless-steel bolts, ASTM F 593 and nuts, ASTM F 594
- B. Power-Actuated Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- C. Mechanical Fasteners: ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
1. Head Type: Low-profile head beneath sheathing; manufacturer's standard elsewhere.
- D. Welding Electrodes: Comply with AWS standards.

2.8 MISCELLANEOUS MATERIALS

- A. Galvanizing Repair Paint: ASTM A 780/A 780M, MIL-P-21035B, or SSPC-Paint 20.
- B. Sealer Gaskets: Closed-cell neoprene foam, 1/4 inch (6 mm) thick, selected from manufacturer's standard widths to match width of bottom track or rim track members as required.

2.9 FABRICATION

- A. Fabricate cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI's specifications and standards, manufacturer's written instructions, and requirements in this Section.
1. Fabricate framing assemblies using jigs or templates.
 2. Cut framing members by sawing or shearing; do not torch cut.
 3. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, pneumatic pin fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted.
 - a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 - b. Locate mechanical fasteners and install according to Shop Drawings, with screws penetrating joined members by no fewer than three exposed screw threads.

4. Fasten other materials to cold-formed steel framing by welding, bolting, pneumatic pin fastening, or screw fastening, according to Shop Drawings.
- B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies by means that prevent damage or permanent distortion.
- C. Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable variation of 1/8 inch in 10 feet (1:960) and as follows:
 1. Spacing: Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
 2. Squareness: Fabricate each cold-formed steel framing assembly to a maximum out-of-square tolerance of 1/8 inch (3 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, conditions, and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

3.3 INSTALLATION, GENERAL

- A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.
- B. Install cold-formed steel framing according to AISI S200, AISI S202, and manufacturer's written instructions unless more stringent requirements are indicated.
- C. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.
 1. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch (1.6 mm).
- D. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
 1. Cut framing members by sawing or shearing; do not torch cut.
 2. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.

- a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 - b. Locate mechanical fasteners, install according to Shop Drawings, and comply with requirements for spacing, edge distances, and screw penetration.
- E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.
- F. Install temporary bracing and supports to secure framing and support loads equal to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
- G. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.
- H. Install insulation, specified in Section 072100 "Thermal Insulation," in framing-assembly members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.
- I. Fasten hole-reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

3.4 EXTERIOR NON-LOAD-BEARING WALL INSTALLATION

- A. Install continuous tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure.
- B. Fasten both flanges of studs to top and bottom track unless otherwise indicated. Space studs as follows:
 - 1. Stud Spacing: As indicated on Drawings.
- C. Set studs plumb, except as needed for diagonal bracing or required for non-plumb walls or warped surfaces and similar requirements.
- D. Isolate non-load-bearing steel framing from building structure to prevent transfer of vertical loads while providing lateral support.
 - 1. Install double deep-leg deflection tracks and anchor outer track to building structure.
- E. Install horizontal bridging in wall studs, spaced vertically in rows indicated on Shop Drawings but not more than 48 inches (1220 mm) apart. Fasten at each stud intersection.
 - 1. Channel Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs.
- F. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.5 ERECTION TOLERANCES

- A. Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 - 1. Space individual framing members no more than plus or minus 1/8 inch (3 mm) from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.6 FIELD QUALITY CONTROL

- A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Field and shop welds will be subject to testing and inspecting.
- C. Testing agency will report test results promptly and in writing to Contractor and Architect.
- D. Cold-formed steel framing will be considered defective if it does not pass tests and inspections.
- E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.7 REPAIRS AND PROTECTION

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A 780/A 780M and manufacturer's written instructions.
- B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that cold-formed steel framing is without damage or deterioration at time of Substantial Completion.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 054000

SECTION 05 50 00 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Steel framing and supports for mechanical and electrical equipment.
2. Steel framing and supports for applications where framing and supports are not specified in other Sections.
3. Elevator machine room hoist beams.
4. Steel shapes for supporting elevator door sills.
5. Shelf angles.
6. Metal ladders.
7. Elevator pit sump covers.
8. Structural-steel door frames.
9. Miscellaneous steel trim including steel angle corner guards and steel edgings.
10. Metal bollards.
11. Loose bearing and leveling plates for applications where they are not specified in other Sections.

B. Products furnished, but not installed, under this Section include the following:

1. Loose steel lintels.
2. Anchor bolts, steel pipe sleeves, slotted-channel inserts, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.
3. Steel weld plates and angles for casting into concrete for applications where they are not specified in other Sections.

C. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for installing anchor bolts, steel pipe sleeves, slotted-channel inserts, wedge-type inserts, and other items cast into concrete.
2. Section 042000 "Concrete Unit Masonry" for installing loose lintels, anchor bolts, and other items built into unit masonry.
3. Section 051200 "Structural Steel Framing."
4. Section 099113 "Exterior Painting."
5. Section 099600 "High Performance Coatings."

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Paint products.
 - 2. Grout.
- B. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide Shop Drawings for the following:
 - 1. Steel framing and supports for mechanical and electrical equipment.
 - 2. Steel framing and supports for applications where framing and supports are not specified in other Sections.
 - 3. Elevator machine beams, hoist beams.
 - 4. Steel shapes for supporting elevator door sills.
 - 5. Shelf angles.
 - 6. Metal ladders.
 - 7. Elevator pit sump covers.
 - 8. Structural-steel door frames.
 - 9. Miscellaneous steel trim including steel angle corner guards and steel edgings.
 - 10. Metal bollards.
 - 11. Loose steel lintels.
- C. Delegated-Design Submittal: For ladders including analysis data signed and sealed by the qualified professional engineer licensed in the Commonwealth of Virginia and responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer.
- B. Mill Certificates: Signed by stainless-steel manufacturers, certifying that products furnished comply with requirements.
- C. Welding certificates.
- D. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

- E. Research/Evaluation Reports: For post-installed anchors, from ICC-ES.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.7 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 METALS

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- C. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666, Type 316L.
- D. Stainless-Steel Bars and Shapes: ASTM A 276, Type 316L.
- E. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.
- F. Rolled-Stainless-Steel Floor Plate: ASTM A 793.
- G. Steel Tubing: ASTM A 500/A 500M, cold-formed steel tubing.

- H. Steel Pipe: ASTM A 53/A 53M, Standard Weight (Schedule 40) unless otherwise indicated.
- I. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.
 - 1. Size of Channels: 1-5/8 by 1-5/8 inches (41 by 41 mm).
 - 2. Material: Galvanized steel, ASTM A 653/A 653M, commercial steel, Type B, with G90 (Z275) coating; 0.108-inch nominal thickness.
- J. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

2.3 FASTENERS

- A. General: Unless otherwise indicated, provide Type 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
 - 1. Provide stainless-steel fasteners for fastening stainless steel.
- B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with hex nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.
- C. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 325, Type 3 (ASTM A 325M, Type 3); with hex nuts, ASTM A 563, Grade C3 (ASTM A 563M, Class 8S3); and, where indicated, flat washers.
- D. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F 593 (ASTM F 738M); with hex nuts, ASTM F 594 (ASTM F 836M); and, where indicated, flat washers; Alloy Group 2 (A4).
- E. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563 (ASTM A 563M); and, where indicated, flat washers.
 - 1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.
- F. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488/E 488M, conducted by a qualified independent testing agency.
- G. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F 2329.
- H. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.

1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 2 (A4) stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).
- I. Slotted-Channel Inserts: Cold-formed, hot-dip galvanized-steel box channels (struts) complying with MFMA-4, 1-5/8 by 7/8 inches (41 by 22 mm) by length indicated with anchor straps or studs not less than 3 inches (75 mm) long at not more than 8 inches (200 mm) o.c. Provide with temporary filler and tee-head bolts, complete with washers and nuts, all zinc-plated to comply with ASTM B 633, Class Fe/Zn 5, as needed for fastening to inserts.

2.4 MISCELLANEOUS MATERIALS

- A. Shop Primers: Provide primers that comply with Section 099100 "Painting" and Section 099600 "High Performance Coatings".
- B. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.
- C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.
- E. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- F. Concrete: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, concrete with a minimum 28-day compressive strength of 4000 psi (20 MPa).

2.5 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- J. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches (3.2 by 38 mm), with a minimum 6-inch (150-mm) embedment and 2-inch (50-mm) hook, not less than 8 inches (200 mm) from ends and corners of units and 24 inches (600 mm) o.c., unless otherwise indicated.

2.6 MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.
- B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.
1. Fabricate units from slotted channel framing where indicated.
 2. Furnish inserts for units installed after concrete is placed.
- C. Galvanize miscellaneous framing and supports where indicated.
- D. Prime miscellaneous framing and supports with primer specified in Section 099113 "Exterior Painting" where indicated.

2.7 SHELF ANGLES

- A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch (19-mm) bolts, spaced not more than 6 inches (150 mm) from ends and 24 inches (600 mm) o.c., unless otherwise indicated.
1. Provide mitered and welded units at corners.

2. Provide open joints in shelf angles at expansion and control joints. Make open joint approximately 2 inches (50 mm) larger than expansion or control joint.

- B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete.
- C. Galvanize shelf angles located in exterior walls.
- D. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

2.8 METAL LADDERS

- A. General:
 1. For elevator pit ladders, comply with ASME A17.1/CSA B44.

2.9 ELEVATOR PIT SUMP COVERS

- A. Fabricate from welded or pressure-locked steel bar grating as indicated.
- B. Provide steel angle supports as indicated.

2.10 MISCELLANEOUS STEEL TRIM

- A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.
- B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.
 1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.
- C. Galvanize miscellaneous steel trim.
- D. Primer specified in Section 099113 "Exterior Painting."

2.11 METAL BOLLARDS

- A. Fabricate metal bollards from Schedule 40 steel pipe.
- B. Prime bollards with primer specified in Section 099113 "Exterior Painting."

2.12 LOOSE BEARING AND LEVELING PLATES

- A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

- B. Galvanize plates.

2.13 LOOSE STEEL LINTELS

- A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Fabricate in single lengths for each opening unless otherwise indicated. Weld adjoining members together to form a single unit where indicated.
- B. Size loose lintels to provide bearing length at each side of openings equal to 1/12 of clear span, but not less than 8 inches (200 mm) unless otherwise indicated.
- C. Galvanize loose steel lintels located in exterior walls.

2.14 STEEL WELD PLATES AND ANGLES

- A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.15 FINISHES, GENERAL

- A. Finish metal fabrications after assembly.
- B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.16 STEEL FINISHES

- A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel hardware and with ASTM A 123/A 123M for other steel and iron products.
 - 1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
- B. Preparation for Shop Priming Galvanized Items: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.
- C. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
- D. Preparation for Shop Priming: Prepare surfaces to comply with requirements indicated below:
 - 1. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - 2. Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - 3. Other Items: SSPC-SP 3, "Power Tool Cleaning."

- E. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
 - 1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- C. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- F. Corrosion Protection: Coat concealed surfaces of aluminum that come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
 - 1. Cast Aluminum: Heavy coat of bituminous paint.
 - 2. Extruded Aluminum: Two coats of clear lacquer.

3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.
- B. Support steel girders on solid grouted masonry, concrete, or steel pipe columns. Secure girders with anchor bolts embedded in grouted masonry or concrete or with bolts through top plates of pipe columns.
 - 1. Where grout space under bearing plates is indicated for girders supported on concrete or masonry, install as specified in "Installing Bearing and Leveling Plates", Article 3.5.

- C. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in "Installing Bearing and Leveling Plates", Article 3.5.
 - 1. Grout baseplates of columns supporting steel girders after girders are installed and leveled.

3.3 INSTALLING METAL BOLLARDS

- A. Fill bollards solidly with concrete, mounding top surface to shed water.

3.4 INSTALLING BEARING AND LEVELING PLATES

- A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of plates.
- B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with nonshrink grout. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.5 ADJUSTING AND CLEANING

- A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - 1. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint as specified.
- C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 05 50 00

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SECTION 05 51 13 - METAL PAN STAIRS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Preassembled steel stairs with concrete-filled and abrasive-coating-finished, formed-metal treads.
 - 2. Railings and guards attached to metal stairs.
 - 3. Handrails attached to walls adjacent to metal stairs.

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written instructions to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for metal stairs, railings, and guards.
 - 1. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry.
 - 2. Deliver such items to Project site in time for installation.
- C. Schedule installation of railings and guards so wall attachments are made only to completed walls.
 - 1. Do not support railings and guards temporarily by any means that do not satisfy structural performance requirements.
- D. Schedule installation of railings and guards so wall attachments are made only to completed walls.
 - 1. Do not support railings and guards temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

- A. Product Data: For metal pan stairs and the following:

1. Prefilled metal-pan-stair treads.
2. Abrasive nosings.
3. Shop primer products.
4. Handrail wall brackets.
5. Grout.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Environmental product declaration.
3. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.

C. Shop Drawings:

1. Include plans, elevations, sections, details, and attachments to other work.
2. Indicate sizes of metal sections, thickness of metals, profiles, holes, and field joints.
3. Include plan at each level.
4. Indicate locations of anchors, weld plates, and blocking for attachment of wall-mounted handrails.

D. Samples for Verification: For each type and finish of nosing.

E. Delegated-Design Submittal: For stairs, railings and guards, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer's experience with providing delegated-design engineering services of the kind indicated, including documentation that engineer is licensed in the jurisdiction in which Project is located.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification.
 - 1. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers.
 - 2. Protect steel members and packaged materials from corrosion and deterioration.
 - 3. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures.
 - a. Repair or replace damaged materials or structures as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Division 1, to design stairs, railings and guards, including attachment to building construction.
- B. Structural Performance of Stairs: Metal stairs shall withstand the effects of gravity, wind and other applicable loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Uniform Load: 100 lbf/sq. ft. (4.79 kN/sq. m).
 - 2. Concentrated Load: 300 lbf (1.33 kN) applied on an area of 4 sq. in. (2580 sq. mm).
 - 3. Uniform and concentrated loads need not be assumed to act concurrently.
 - 4. Stair Framing: Capable of withstanding stresses resulting from railing and guard loads in addition to loads specified above.
 - 5. Limit deflection of treads, platforms, and framing members to L/360 or 1/4 inch (6.4 mm), whichever is less.
- C. Structural Performance of Railings and Guards: Railings and guards, including attachment to building construction, shall withstand the effects of gravity, wind and other applicable loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
 - 3. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

- a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- D. Seismic Performance of Stairs: Metal stairs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and all applicable codes including VUSBC/IBC.

2.2 METALS

- A. Metal Surfaces: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
 - 1. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- C. Steel Pipe for Railings and Guards: ASTM A53/A53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
 - 1. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
 - 2. Provide galvanized finish for exterior installations and where indicated.
- D. Galvanized-Steel Sheet: ASTM A653/A653M, G90 (Z275) coating, structural steel, Grade 33 (Grade 230), unless another grade is required by design loads.
 - 1. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25percent.

2.3 ABRASIVE NOSINGS

- A. Cast-Metal Units: Cast aluminum, with an integral abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. American Safety Tread Co., Inc.
 - b. Barry Pattern & Foundry Co., Inc.
 - c. Safe-T-Metal Company, Inc.
 - 2. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
 - 3. Configuration: Cross-hatched units, 3 inches (75 mm) wide without lip.
- B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.

- C. Apply bituminous paint to concealed surfaces of cast-metal units set into concrete.

2.4 FASTENERS

- A. General: Provide zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 12 for exterior use, and Class Fe/Zn 5 where built into exterior walls.
 - 1. Select fasteners for type, grade, and class required.
- B. Fasteners for Anchoring Railings and Guards to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings and guards to other types of construction indicated and capable of withstanding design loads.
- C. Bolts, nuts, and washers: ASTM A 325 (ASTM A 325M), Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C (ASTM, Class 8S) heavy-hex carbon-steel nuts; and ASTM F 436 (ASTM F 436M), Type 1, hardened carbon-steel washers; finish to be selected by architect from manufacturers standard finishes.
- D. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563 (ASTM A563M); and, where indicated, flat washers.
 - 1. Provide mechanically deposited or hot-dip, zinc-coated anchor bolts for exterior stairs.
- E. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
 - 1. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy stainless-steel bolts, ASTM F593, and nuts, ASTM F594 (ASTM F836M).
 - 2. Concrete: Basis of Design - Hilti-Hy-100, or approved equal.
 - 3. Concrete Masonry Units: Basis of Design – Hilti-HLC, or approved equal.

2.5 MISCELLANEOUS MATERIALS

- A. Handrail Wall Brackets: Cast stainless steel, center of rail 2-1/2 inches (63.5 mm) from face of wall.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Blum, Julius & Co., Inc.
 - b. The Wagner Companies., R&B Wagner, Inc.
- B. Welding Electrodes: Comply with AWS requirements.

- C. Shop Primers: Provide primers that comply with Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
- D. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - 1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- E. Zinc-Rich Primer: Comply with SSPC-Paint 20, Type II, Level 2, and compatible with topcoat.
- F. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish system indicated.
- G. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- H. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- I. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, nonmetallic aggregate grout; recommended by manufacturer for exterior use; noncorrosive and nonstaining; mixed with water to consistency suitable for application and a 30-minute working time.
- J. Prefilled Concrete Treads:
 - 1. Concrete Materials and Properties: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mix concrete with minimum 28-day compressive strength of 3000 psi (20 MPa) and maximum aggregate size of 1/2 inch (13 mm) unless otherwise indicated.
 - 2. Nonslip-Aggregate Concrete Finish: Factory-packaged abrasive aggregate made from fused, aluminum-oxide grits or crushed emery; rustproof and nonglazing; unaffected by freezing, moisture, or cleaning materials.
 - 3. Plain Steel Welded-Wire Reinforcement: ASTM A1064/A10645M, steel, 6 by 6 inches (152 by 152 mm), W1.4 by W1.4, unless otherwise indicated on Drawings.
 - a. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
 - 4. Reinforcement Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening welded-wire reinforcement in place.
 - a. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete.
- K. For galvanized reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.

2.6 FABRICATION, GENERAL

- A. Provide complete stair assemblies, including metal framing, hangers, struts, railings and guards, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
 - 1. Join components by welding unless otherwise indicated.
 - 2. Use connections that maintain structural value of joined pieces.
- B. Assemble stairs, railings, and guards in shop to greatest extent possible.
 - 1. Disassemble units only as necessary for shipping and handling limitations.
 - 2. Clearly mark units for reassembly and coordinated installation.
- C. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- D. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- E. Form exposed work with accurate angles and surfaces and straight edges.
- F. Weld connections to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Weld exposed corners and seams continuously unless otherwise indicated.
 - 5. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Finish #1 - No evidence of welded joint.
- G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible.
 - 1. Where exposed fasteners are required, use Tamper Proof flat-head (countersunk) screws or bolts unless otherwise indicated.
 - 2. Locate joints where least conspicuous.
 - 3. Fabricate joints that will be exposed to weather in a manner to exclude water.
 - 4. Provide weep holes where water may accumulate internally.

2.7 FABRICATION OF STEEL-FRAMED STAIRS

- A. NAAMM Stair Standard: Comply with NAAMM AMP 510, "Metal Stairs Manual," for Commercial Class, unless more stringent requirements are indicated.
- B. Stair Framing:

1. Fabricate stringers as indicated on Drawings.
 - a. Stringer Size: As indicated on Drawings.
 - b. Provide closures for exposed ends of channel and rectangular tube stringers.
 - c. Finish: Galvanized.
 2. Construct platforms of steel headers and miscellaneous framing members as required to comply with "Performance Requirements" Article and as indicated on Drawings.
 - a. Provide closures for exposed ends of channel and rectangular tube framing.
 - b. Finish: Galvanized.
 3. Weld stringers to headers; weld framing members to stringers and headers.
 4. Where masonry walls support metal stairs, provide temporary supporting struts designed for erecting steel stair components before installing masonry.
- C. Metal Pan Stairs: Form risers, subreads pans, and subplatforms to configurations shown from steel sheet of thickness needed to comply with performance requirements, but not less than 0.067 inch (1.7 mm).
1. Fabricate treads and landing subplatforms of exterior stairs so finished walking surfaces slope to drain.
 2. Steel Sheet: Uncoated, cold or hot-rolled steel sheet unless otherwise indicated.
 3. Steel Sheet: Galvanized-steel sheet.
 4. Directly weld metal pans to stringers; locate welds on top of subreads where they will be concealed by concrete fill. Do not weld risers to stringers.
 5. Attach risers and subreads to stringers with brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding, riveting, or bolting.
 6. Shape metal pans to include nosing integral with riser.
 7. Attach abrasive nosings to risers.
 8. At Contractor's option, provide stair assemblies with metal pan subreads filled with reinforced concrete during fabrication.
 9. Provide subplatforms of configuration indicated or, if not indicated, the same as subreads. Weld subplatforms to platform framing.

2.8 FABRICATION OF STAIR RAILINGS AND GUARDS

- A. Comply with applicable requirements in Section 055213 "Pipe and Tube Railings."
- B. Fabricate railings and guards to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of member, post spacings, wall bracket spacing, and anchorage, but not less than that needed to withstand indicated loads.
 1. Rails and Posts: 1-5/8-inch- (41-mm-) diameter top and bottom rails and 1-1/2-inch- (38-mm-) square posts.
 2. Mesh Infill: Coordinate stair work with mesh installation. Confirm that the mesh infill is being used as the guard in lieu of a pipe rail. Mesh infill to be designed and installed to satisfy the requirements of a guard.

- C. Welded Connections: Fabricate railings and guards with welded connections.
 - 1. Fabricate connections that are exposed to weather in a manner that excludes water.
 - a. Provide weep holes where water may accumulate internally.
 - 2. Cope components at connections to provide close fit, or use fittings designed for this purpose.
 - 3. Weld all around at connections, including at fittings.
 - 4. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 5. Obtain fusion without undercut or overlap.
 - 6. Remove flux immediately.
 - 7. Finish welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Finish #1 - No evidence of a welded joint as shown in NAAMM AMP 521.
- D. Form changes in direction of railings and guards as follows:
 - 1. By inserting prefabricated flush-elbow fittings.
- E. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- F. Close exposed ends of railing and guard members with prefabricated end fittings.
- G. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated.
 - 1. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- H. Connect posts to stair framing by direct welding unless otherwise indicated.
- I. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting components and for attaching to other work.
 - 1. Furnish inserts and other anchorage devices for connecting to concrete or masonry work.
 - 2. For galvanized railings and guards, provide galvanized fittings, brackets, fasteners, sleeves, and other ferrous-metal components.
 - 3. For nongalvanized railings and guards, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors embedded in exterior masonry and concrete construction.
 - 4. Provide type of bracket with flange tapped for concealed anchorage to threaded hanger bolt and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall surface.
- J. Fillers: Provide fillers made from steel plate, or other suitably crush-resistant material, where needed to transfer wall bracket loads through wall finishes to structural supports.
 - 1. Size fillers to suit wall finish thicknesses and to produce adequate bearing area to prevent bracket rotation and overstressing of substrate.

2.9 FINISHES

- A. Finish metal stairs after assembly.
- B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
 - 1. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
 - 2. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- C. Preparation for Shop Priming: Prepare uncoated, ferrous-metal surfaces to comply with SSPC-SP 3, "Power Tool Cleaning."
- D. Apply shop primer to uncoated surfaces of metal stair components, except those with galvanized finishes and those to be embedded in concrete or masonry unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify elevations of floors, bearing surfaces and locations of bearing plates, and other embedments for compliance with requirements.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF METAL PAN STAIRS

- A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction.
 - 1. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.
- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.
- C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.
 - 1. Grouted Baseplates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates.
 - a. Clean bottom surface of plates.
 - b. Set plates for structural members on wedges, shims, or setting nuts.

- c. Tighten anchor bolts after supported members have been positioned and plumbed.
- d. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
- e. Promptly pack grout solidly between bearing surfaces and plates so no voids remain.
 - 1) Neatly finish exposed surfaces; protect grout and allow to cure.
 - 2) Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- E. Fit exposed connections accurately together to form hairline joints.
 - 1. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.
 - 2. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
 - 3. Comply with requirements for welding in "Fabrication, General" Article.
- F. Place and finish concrete fill for treads and platforms to comply with Section 033000 "Cast-in-Place Concrete."
 - 1. Install abrasive nosings with anchors fully embedded in concrete.
 - 2. Center nosings on tread width.
- G. Install precast concrete treads with adhesive supplied by manufacturer.

3.3 INSTALLATION OF RAILINGS AND GUARDS

- A. Adjust railing and guard systems before anchoring to ensure matching alignment at abutting joints with tight, hairline joints.
 - 1. Space posts at spacing indicated or, if not indicated, as required by design loads.
 - 2. Plumb posts in each direction, within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 - 3. Align rails and guards so variations from level for horizontal members and variations from parallel with rake of stairs for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
 - 4. Secure posts, rail ends, and guard ends to building construction as follows:
 - a. Anchor posts to steel by welding to steel supporting members.
 - b. Anchor handrail and guard ends to concrete and masonry with steel round flanges welded to rail and guard ends and anchored with post-installed anchors and bolts.
- B. Attach handrails to stair structure and steel columns with brackets.
 - 1. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
 - 2. Secure brackets to structure as required to comply with performance requirements.

3.4 REPAIR

- A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - 1. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
- C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 05 51 13

SECTION 05 52 13 - PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Hot-dip galvanized steel tube railings.
- B. Related Requirements:
 - 1. Section 05 51 12 "Metal Pan Stairs".
 - 2. Section 09 91 13 "Exterior Painting".

1.3 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
- C. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Railing brackets.
 - 2. Post-installed anchors including chemical anchor adhesive when provided.
 - 3. Galvanizing Repair Paint.
 - 4. Paints when not submitted for Section 05 52 13 "Pipe and Tube Railings".
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- C. Samples: For each type of exposed finish required.

1. Assembled Sample of railing system, made from full-size components, including top rail, post, post and base plate, handrail and handrail bracket, and infill. Sample need not be full height.
 - a. Show method of connecting and finishing members at intersections.
- D. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

1.8 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain each type of railing from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Division 1, 01 33 00 Submittal Procedures, to design railings, including attachment to building construction.
- B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 1. Handrails and Top Rails of Guards:

- a. Uniform load of 50 lbf/ ft. applied in any direction.
 - b. Concentrated load of 200 lbf applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
2. Infill of Guards:
 - a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft.
 - b. Infill load and other loads need not be assumed to act concurrently.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.3 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.
 1. Provide type of bracket with predrilled hole for exposed bolt anchorage and that provides 1-1/2-inch clearance from inside face of handrail to finished wall surface.

2.4 STEEL AND IRON

- A. Tubing: ASTM A500 Grade B, unless another grade is required by structural loads.
- B. Plates, Shapes, and Bars: ASTM A36/A36M.

2.5 FASTENERS

- A. General: Provide the following:
 1. Hot-Dip Galvanized Railings: Type 304 stainless-steel or hot-dip zinc-coated steel fasteners complying with ASTM A153/A153M or ASTM F2329 for zinc coating.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.
- C. Fasteners for Interconnecting Railing Components:
 1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.
 2. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.

3. Provide tamper-resistant flat-head machine screws for exposed fasteners unless otherwise indicated.
- D. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to 6 times the load imposed when installed in unit masonry and 4 times the load imposed when installed in concrete, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
 1. Material: Alloy Group 2 stainless-steel bolts, ASTM F593, and nuts, ASTM F594.
 2. Chemical Anchor Adhesive: Epoxy based adhesive formulated for doweling alloy Group 2 stainless steel threaded rod and suitable for use when concrete is wet and when there is standing water in the hole into which the anchor is to be placed.

2.6 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
- B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
- C. Galvanizing Repair Paint: High-zinc-dust-content paint conforming to SSPC-Paint 20, Type II, Level 1 with at least 92 percent metallic zinc (ASTM D520, Type III) by weight in dried film; complying with ASTM A780/A780M; meeting the performance requirements of SSPC-Paint 29, Type II, Level 1; and compatible with paints specified to be used over it.
- D. Shop Primers: Provide primers that comply with Section 099600 "High-Performance Coatings."
- E. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.
- F. Intermediate Coats and Topcoats: Provide products that comply with Section 099600 "High-Performance Coatings."
- G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- H. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.7 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

- C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that are exposed to weather in a manner that excludes water. Provide weep holes where water may accumulate.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
- G. Connections: Fabricate railings with welded connections unless otherwise indicated.
- H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove flux immediately.
 - 4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.
- I. Form Changes in Direction as Follows:
 - 1. By flush bends or by inserting prefabricated flush-elbow fittings.
- J. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- K. Close exposed ends of railing members with prefabricated flush end fittings.
- L. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch or less.
- M. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
- N. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.
- O. Provide anchor plates welded to bottom of posts where posts are to be anchored to concrete.
 - 1. Anchor plates to be circular, square, or rectangular, of length, width, and thickness capable of withstanding loads imposed by railings and of size capable of transferring loads imposed by railing to post-installed anchors and concrete substrate. Anchor plate thickness to be not less than 3/8 inch.
 - 2. All corners of square and rectangular anchor plates are to be radiused 1/4 inch.

2.8 STEEL AND IRON FINISHES

A. Galvanized Railings:

1. Hot-dip galvanize steel railings, including hardware, after fabrication.
2. Comply with ASTM A123/A123M for hot-dip galvanized railings.
3. Comply with ASTM A153/A153M for hot-dip galvanized hardware.
4. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
5. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

B. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.

C. Preparing Galvanized Railings for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.

D. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

E. Shop-Painted Finish: Section 09 91 00 "Painting".

1. Color: As indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.

C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

D. Adjust railings before anchoring to ensure matching alignment at abutting joints.

E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.2 RAILING CONNECTIONS

- A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.
- B. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.3 ANCHORING POSTS

- A. Anchor posts to concrete surfaces with post-installed anchors to support structural loads.

3.4 ATTACHING RAILINGS

- A. Anchor railing ends at walls with round flanges anchored to wall construction and welded to railing ends.
- B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends.
- C. Attach railings to wall with wall brackets. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
- D. Secure wall brackets and railing end flanges to building construction as follows:
 - 1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
 - 2. For hollow masonry anchorage, use toggle bolts.
 - 3. For steel-framed partitions, use self-tapping screws fastened to steel framing or to concealed steel reinforcements.

3.5 ADJUSTING AND CLEANING

- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas. Repair galvanizing with paints containing zinc dust to comply with ASTM A780/A780M. Apply paint in accordance with manufacturer's written instructions. The minimum total thickness of painted dry film coating is to be equal to the hot dip galvanized layer. Apply in multiple coats as necessary to comply with manufacturer's written instructions.
 - 1. Cleaning of grease, oils, and other soluble contaminants: Solvent clean to SSPC-SP1.
 - 2. Removal of rust, mill scale, and other detrimental foreign matter: Hand tool clean to SSPC-SP2. Power tool clean as necessary to SSPC-SP3.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 09 91 00 "Painting".

3.6 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 05 52 13

SECTION 05 73 01 - DECORATIVE METAL PANELS -WIRE MESH

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Stainless steel decorative wire mesh panels for Stairs #1, 2,3 and the Pedestrian Bridge.
- B. Related Requirements:
 - 1. Section 055213 "Pipe and Tube Railings" for nonornamental railings fabricated from pipes and tubes.

1.3 COORDINATION AND SCHEDULING

- A. Coordinate installation of anchorages for panels. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts. Deliver items to Project site in time for installation.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. Manufacturer's product lines of decorative metal railings assembled from standard components.
 - 2. Woven-wire mesh infill panels.
 - 3. Fasteners.
 - 4. Post-installed anchors.
 - 5. Bituminous paint.
 - 6. Metal finishes.
- B. Shop Drawings: Include plans, elevations, sections, and attachment details.
- C. Samples for Initial Selection: For products involving selection of color, texture, or design including finishes.
- D. Samples for Verification: For each type of exposed finish required.

1. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters
2. Fittings, end caps, and brackets.
3. Assembled Sample of mesh panel system, made from full-size components. Sample need not be full height.

a. Show method of connecting members at intersections.

- E. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Calculations shall be stamped by a licensed PE.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For tests on wire mesh panels performed by a qualified testing agency, in accordance with ASTM E894 and ASTM E935.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect mechanical finishes on exposed surfaces of railings from damage by applying a strippable, temporary protective covering before shipping.

1.7 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 25 00 "Submittal Procedures" to design mesh panels, including attachment to building construction.

- B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1. Wire Mesh Infill panels:

- a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft.
- b. Infill load and other loads need not be assumed to act concurrently.

- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior railings by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Same metal and finish as supported wire mesh panels unless otherwise indicated.

2.3 STAINLESS STEEL DECORATIVE WIRE MESH PANELS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. Edward J Darby & Son Inc.
 2. Kane Innovations, Inc.
 3. McNichols Company
- B. Source Limitations: Obtain stainless steel decorative railing components from single source from single manufacturer.
- C. Tubing: ASTM A554, Grade MT 304.
- D. Pipe: ASTM A312/A312M, Grade TP 304.
- E. Plate, Sheet, and Strip: ASTM A240/A240M or ASTM A666, Type 304.
- F. Flat Bar: ASTM A666, Type 304.
- G. Frame: Stainless Steel U-Channel minimum 14 ga. corners welded and ground smooth to assure minimum maintenance and allow water to escape, drain holes in the bottom side and corners of the panels shall be provided. Frame of panel to be electro-polished. Wire brush finish is not acceptable.
- H. Bars and Shapes: ASTM A276/A276M, Type 304.
- I. Woven-Wire Mesh Infill Panels: Pedestrian Bridge Panels Intermediate-crimp weave, square pattern, 1.0" x 1.0" square woven-wire mesh, made from a minimum 0.120-inch nominal diameter stainless steel wire complying with ASTM A580/A580M, Type 304.
- J. Woven-Wire Mesh Infill Panels: Stairs #1, 2 and 3 Panels Intermediate-crimp weave, square pattern, 2.0" x 4.0" rectangular woven-wire mesh, made from a minimum 0.105-inch nominal diameter stainless steel wire complying with ASTM A580/A580M, Type 304.

2.4 FASTENERS

- A. Fastener Materials:
 1. Stainless Steel Railing Components: Type 304 stainless steel fasteners.

2. Dissimilar Metal Railing Components: Type 304 stainless steel fasteners.

- B. Fasteners for Anchoring to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction and capable of withstanding design loads.
- C. Provide exposed fasteners as indicated.
 - 1. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 stainless steel bolts, ASTM F593 and nuts, ASTM F594.

2.5 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - 1. For stainless steel railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- B. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.6 FABRICATION

- A. Fabricate wire mesh panels to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- B. Shop assemble wire mesh panels to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations.
 - 1. Clearly mark units for reassembly and coordinated installation.
 - 2. Use connections that maintain structural value of joined pieces.
- C. Cut, drill, and punch metals cleanly and accurately.
 - 1. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated.
 - 2. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that will be exposed to weather in a manner to exclude water.
 - 1. Provide weep holes where water may accumulate.
 - 2. Locate weep holes in inconspicuous locations.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

- G. Connections: Fabricate wire mesh panels with mechanical connections unless otherwise indicated.
- H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove flux immediately.
 - 4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Finish #1 welds; ornamental quality with no evidence of a welded joint.
- I. Mechanical Connections: Connect members with concealed mechanical fasteners and fittings.
 - 1. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
 - 2. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.
- J. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, handrail brackets, miscellaneous fittings, and anchors to interconnect railing members to other Work unless otherwise indicated.
- K. Provide inserts and other anchorage devices for connecting railings to concrete or masonry Work.
 - 1. Fabricate anchorage devices capable of withstanding loads imposed by railings.
 - 2. Coordinate anchorage devices with supporting structure.
 - 3. Delete first paragraph below if no posts are set in concrete or if posts are set without sleeves.
 - 4. Provide socket covers designed and fabricated to resist being dislodged.
 - 5. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
- L. Woven-Wire Mesh Infill Panels: Fabricate infill panels from woven-wire mesh crimped into 1-by-1/2-by-1/8-inch metal channel frames.
 - 1. Fabricate wire mesh and frames from stainless steel.
 - 2. Orient wire mesh with wires horizontal and vertical.

2.7 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipment.

- C. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- D. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

2.8 STAINLESS STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1. Run grain of directional finishes with long dimension of each piece.
 - 2. When polishing is completed, passivate and rinse surfaces.
 - 3. Remove embedded foreign matter and leave surfaces chemically clean.
- C. Stainless Steel Sheet and Plate Finishes:
 - 1. Directional Satin Finish: ASTM A480/A480M, No. 4.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Perform cutting, drilling, and fitting required for installing railings.
 - 1. Fit exposed connections together to form tight, hairline joints.
 - 2. Install railings level, plumb, square, true to line; without distortion, warp, or rack.
 - 3. Set railings accurately in location, alignment, and elevation; measured from established lines and levels.
 - 4. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 - 5. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
 - 6. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.
- B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.
 - 1. Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- C. Adjust mesh panels before anchoring to ensure matching alignment at abutting joints.

- D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.2 WIRE MESH CONNECTIONS

- A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components.
- B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article, whether welding is performed in the shop or in the field.
- C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve, extending 2 inches beyond joint on either side; fasten internal sleeve securely to one side; and locate joint within 6 inches of post.

3.3 CLEANING

- A. Clean stainless steel by washing thoroughly with clean water and soap, rinsing with clean water, and wiping dry.

3.4 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period, so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit or provide new units.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 05 73 00

SECTION 06 10 53 - MISCELLANEOUS ROUGH CARPENTRY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Wood blocking and nailers.
 - 2. Plywood backing panels.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
 - 2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
 - 3. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D5664.
 - 4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant-treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Stack lumber flat with spacers beneath and between each bundle to provide air circulation. Protect lumber from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

- A. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 - 1. Factory mark each piece of lumber with grade stamp of grading agency.
 - 2. Dress lumber, S4S, unless otherwise indicated.
- B. Maximum Moisture Content of Lumber: 19 percent unless otherwise indicated.

2.2 WOOD-PRESERVATIVE-TREATED MATERIALS

- A. Preservative Treatment by Pressure Process: AWP A U1; Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.
 - 1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.
- B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or does not comply with requirements for untreated material.
- C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
- D. Application: Treat the following:
 - 1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, roof specialties, flashing, vapor barriers, and waterproofing.
 - 2. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
 - 3. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.

2.3 FIRE-RETARDANT-TREATED MATERIALS

- A. General: Where fire-retardant-treated materials are indicated, materials shall comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested according to ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
 - 1. Treatment shall not promote corrosion of metal fasteners.
 - 2. Exterior Type: Treated materials shall comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering according to ASTM D2898. Use for exterior locations where indicated and interior locations.
- C. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Kiln-dry plywood after treatment to a maximum moisture content of 15 percent.
- D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency.
- E. Application: Treat the following:
 - 1. Plywood backing panels.

2.4 MISCELLANEOUS LUMBER

- A. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - 1. Blocking.
 - 2. Nailers.
 - 3. Rooftop equipment bases and support curbs.
 - 4. Furring.
 - 5. Grounds.
- B. Dimension Lumber Items: Construction or No. 2 grade lumber of any of the following species:
 - 1. Hem-fir (north); NLGA.
 - 2. Mixed southern pine or southern pine; SPIB.
 - 3. Spruce-pine-fir; NLGA.
 - 4. Hem-fir; WCLIB or WWPA.
 - 5. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.

- C. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.
- D. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.
- E. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

2.5 PLYWOOD BACKING PANELS

- A. Equipment Backing Panels: Plywood, DOC PS 1, Exterior, A-C fire-retardant treated, in thickness indicated or, if not indicated, not less than 3/4-inch nominal thickness.

2.6 FASTENERS

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
 - 1. Where carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.
- B. Nails, Brads, and Staples: ASTM F1667.
- C. Screws for Fastening to Metal Framing: ASTM C954, length as recommended by screw manufacturer for material being fastened.
- D. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

2.7 METAL FRAMING ANCHORS

- A. Galvanized-Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A653/A653M, G60 coating designation.
 - 1. Use for interior locations unless otherwise indicated.
- B. Hot-Dip, Heavy-Galvanized Steel Sheet: ASTM A653/A653M; Structural Steel (SS), high-strength low-alloy steel Type A (HSLAS Type A), or high-strength low-alloy steel Type B (HSLAS Type B); G185 coating designation; and not less than 0.036 inch thick.
 - 1. Use for wood-preservative-treated lumber and where indicated.
- C. Stainless Steel Sheet: ASTM A240/A240M or ASTM A666, Type 304 or Type 316.
 - 1. Use for exterior locations and where indicated.

2.8 MISCELLANEOUS MATERIALS

- A. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.025 inch.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Framing Standard: Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.
- B. Set carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit carpentry accurately to other construction. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.
- C. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels. Install fire-retardant-treated plywood backing panels with classification marking of testing agency exposed to view.
- D. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- E. Comply with AWWA M4 for applying field treatment to cut surfaces of preservative-treated lumber.
 - 1. Use copper naphthenate for items not continuously protected from liquid water.
- F. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.
- G. Securely attach carpentry work to substrate. Comply with requirements of authorities having jurisdiction.

3.2 INSTALLATION OF WOOD BLOCKING AND NAILER

- A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.
- B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.

3.3 INSTALLATION OF WOOD FURRING

- A. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.
- B. Furring to Receive Plywood or Hardboard Paneling: Install 1-by-3-inch nominal- size furring horizontally and vertically at 24 inches o.c. maximum.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 06 10 53

SECTION 06 16 00 - SHEATHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Wall sheathing.
 - 2. Roof sheathing.
 - 3. Parapet sheathing.

- B. Related Requirements:

- 1. Section 07 27 26 "Fluid-Applied Membrane Air Barriers" for fluid-applied air barrier over wall and parapet sheathing.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1.4 INFORMATIONAL SUBMITTALS

- A. Evaluation Reports: For the following, from ICC-ES:

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Stack panels flat with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WALL SHEATHING

- A. Glass-Mat Gypsum Sheathing: ASTM C1177/C1177M.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Georgia-Pacific Gypsum LLC.
 - b. National Gypsum Company.
 - c. USG Corporation.
2. Type and Thickness: Type X, As indicated.
3. Size: 48 by 120 inches for vertical installation.

B. Cementitious Backer Units: ASTM C1325, Type A.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. C-Cure.
 - b. Custom Building Products.
 - c. USG Corporation.
2. Thickness: 1/2 inch.

2.2 PARAPET SHEATHING

A. Glass-Mat Gypsum Sheathing: ASTM C1177/C1177M.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Georgia-Pacific Gypsum LLC.
 - b. National Gypsum Company.
 - c. USG Corporation.
2. Type and Thickness: Type X, 5/8 inch.
3. Size: 48 by 96 inches for vertical installation.

2.3 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.

1. For roof, parapet, and wall sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.

B. Screws for Fastening Gypsum Sheathing to Cold-Formed Metal Framing: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing to be attached.

1. For steel framing from 0.033 to 0.112 inch thick, use screws that comply with ASTM C954.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.
- B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
- C. Securely attach to substrate by fastening as indicated, complying with the following:
 - 1. ICC-ES evaluation report for fastener.
- D. Coordinate wall, parapet, and roof sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.
- E. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.
- F. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.
 - 1. Wall and Roof Sheathing:
 - a. Screw to cold-formed metal framing.
 - b. Space panels 1/8 inch apart at edges and ends.

3.2 GYPSUM SHEATHING INSTALLATION

- A. Comply with GA-253 and with manufacturer's written instructions.
 - 1. Fasten gypsum sheathing to cold-formed metal framing with screws.
 - 2. Install panels with a 3/8-inch gap where non-load-bearing construction abuts structural elements.
 - 3. Install panels with a 1/4-inch gap where they abut masonry or similar materials that might retain moisture, to prevent wicking.
- B. Apply fasteners so heads bear tightly against face of sheathing, but do not cut into facing.
 - 1. Space fasteners approximately 8 inches o.c. and set back a minimum of 3/8 inch from edges and ends of panels.
- C. Vertical Installation: Install vertical edges centered over studs. Abut ends and edges with those of adjacent panels. Attach at perimeter and within field of panel to each stud.
 - 1. Space fasteners approximately 8 inches o.c. and set back a minimum of 3/8 inch from edges and ends of panels.

3.3 CEMENTITIOUS BACKER UNIT INSTALLATION

- A. Install panels and treat joints according to ANSI A108.11 and manufacturer's written instructions for type of application indicated.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 06 16 00

SECTION 06 64 00 – POLYETHYLENE PLATFORM EDGE STRIPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes polyethylene platform edge strips (rub rail).

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples:
 - 1. Polyethylene platform edge strips: 8-inch lengths
 - 2. Fasteners: Each fastener type.

1.3 QUALITY ASSURANCE

- A. Testing Agency: Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POLYETHYLENE PLATFORM EDGE STRIPS

- A. Edge Strip Size and Configuration.
 - 1. Shapes, profiles, lengths, locations and mounting heights shall be coordinated to comply with vehicle operation requirements.
 - a. Nominal Thickness: 2 inches
 - b. Vertical Width: 7 inches
 - c. Horizontal Strip Length: 10' minimum
 - 2. Recessed counter-sunk mounting holes 2-inches from each end, and maximum 1'-4" on center, for fastening to the concrete platform face.
 - 3. Bearing Capacity: Platform edge strip to be capable of supporting the bearing weight of a person seated in a wheelchair, approximately 800 lbs. over a 38-inch by 48-inch area, plus accepted factors of safety for structural bearing surfaces, while boarding and alighting a transit vehicle.
 - 4. Public transit quality, and suited to withstand local weather conditions including road surface treatments applied during inclement weather.
- B. Edge Strip Material: Ultra-High Molecular Weight Polyethylene (UHMWP)
 - 1. Surface-Burning Characteristics: As follows when tested by a qualified testing agency according to ASTM E 84. Identify products with appropriate markings of applicable testing agency.

- a. Flammability, ASTM E162:
 - 1) Flame Spread: Radiant Panel Index Is = 35 maximum
- b. Smoke Generation, ASTM E662:
 - 1) Flaming Mode: Specific Optical Density = 12 maximum
 - 2) Flaming Mode: Maximum Specific Optical Density Dm = 430 maximum
 - 3) Non-flaming Mode: Specific Optical Density Ds = 8 maximum
 - 4) Non-flaming Mode: Maximum Specific Optical Density Dm = 246 maximum
- c. Smoke Toxicity, ASTM E800:
 - 1) Carbon Monoxide (CO): Maximum 123 ppm, flaming mode
 - 2) Hydrogen Fluoride (HF): Maximum 1.5 ppm, flaming mode
 - 3) Hydrogen Chloride (HCl): Maximum 1.2 ppm, flaming mode
 - 4) Hydrogen Cyanide (HCN): Maximum 2 ppm, flaming mode
 - 5) Nitrogen Oxide (NOx): Maximum 53 ppm, flaming mode
 - 6) Sulfur Oxide (SO2): Maximum 1 ppm, flaming mode
 - 7) Carbon Dioxide (CO2): Maximum 10,000 ppm, flaming mode
2. Coefficient of thermal expansion, degrees Fahrenheit, tested in accordance with ASTM D696 (astm.org), not to exceed:
 - a. 0-deg to 75-deg: 1.1×10^{-4} inches per inch
 - b. 75-deg to 120-deg: 1.87×10^{-4} inches per inch
3. Straightness tolerance, on platform edge side of the edge strip: 1/8-inch in a 120-inch section.
4. Variation in width of strip: Not more than 1/16-inch in any length section.
5. Surface finish: Top (bearing) surface to be scarified in cross-hatch pattern to create a non-slip surface.
6. Color: High visibility yellow or as approved by VRE.
- C. Fasteners:
 1. Bolts: Stainless Steel Type 316; minimum 3/8-inch in lengths required
 2. Lock Washers: Stainless Steel Type 316; sized to match bolt and anchors
 3. Fender Washers: Stainless Steel Type 316; sized to match bolt and anchors
 4. Drop In Anchors: Stainless Steel Type 316; minimum 3/8-inch in lengths required

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products may be incorporated into the Work include, but are not limited to the following:
 1. Polymer Industries Polyslick Bus Curb, or approved equal.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Verify conditions prior to installation.
- B. Clean platform mounting surface of substances including oil, grease, dirt, and dust.

- C. Lay out strips before installing. Locate strip joint so that trimmed strips at ends are not less than 10 feet in length.
- D. Provide scarf joints where two strips meet per manufacturers recommendation. Apply adhesive at scarf joints per manufacturer's instructions. Joints should not be based on direction of vehicle travel as trains will come from either direction.

3.2 INSTALLATION

- A. Install fasteners according to manufacturer's specifications and instructions for edge strip installation.
- B. Edge strip installed tolerance, top (bearing) surface: No greater than 1/8-inch difference in height at juncture of concrete platform and edge strip.
- C. Coordinate anchor locations with concrete and rebar.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 06 64 00

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SECTION 07 13 26 - SELF-ADHERING SHEET WATERPROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Modified bituminous sheet waterproofing.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Shop Drawings: Show locations and extent of waterproofing and details of substrate joints and cracks, expansion joints, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.

1. Include setting drawings showing layout, sizes, sections, profiles, and joint details.

- C. Samples: For each product.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample warranties.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by waterproofing manufacturer.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement waterproofing material for waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.

1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MODIFIED BITUMINOUS SHEET WATERPROOFING

- A. Modified Bituminous Sheet: Minimum 60-mil nominal thickness, self-adhering sheet consisting of 56 mils of rubberized asphalt laminated on one side to a 4-mil- thick, polyethylene-film reinforcement, and with release liner on adhesive side
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlisle Coatings & Waterproofing Inc.
 - b. CETCO, a Minerals Technologies company.
 - c. Henry Company.
 - d. W.R. Meadows, Inc.
 2. Physical Properties:
 - a. Tensile Strength, Membrane: 250 psi minimum; ASTM D 412, Die C, modified.
 - b. Ultimate Elongation: 300 percent minimum; ASTM D 412, Die C, modified.
 - c. Low-Temperature Flexibility: Pass at minus 20 deg F; ASTM D 1970/D 1970M.
 - d. Crack Cycling: Unaffected after 100 cycles of 1/8-inch movement; ASTM C 836/C 836M.
 - e. Puncture Resistance: 40 lbf minimum; ASTM E 154/E 154M.
 - f. Water Absorption: 0.2 percent weight-gain maximum after 48-hour immersion at 70 deg F; ASTM D 570.
 - g. Water Vapor Permeance: 0.05 perm maximum; ASTM E 96/E 96M, Water Method.
 - h. Hydrostatic-Head Resistance: 200 feet minimum; ASTM D 5385.
 3. Sheet Strips: Self-adhering, rubberized-asphalt strips of same material and thickness as sheet waterproofing.

2.2 AUXILIARY MATERIALS

- A. Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.
1. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.
- B. Primer: Liquid solvent-borne primer recommended for substrate by sheet-waterproofing material manufacturer.
- C. Surface Conditioner: Liquid, waterborne surface conditioner recommended for substrate by sheet-waterproofing material manufacturer.
- D. Liquid Membrane: Elastomeric, two-component liquid, cold fluid applied, of trowel grade or low viscosity.

- E. Substrate Patching Membrane: Low-viscosity, two-component, modified asphalt coating.
- F. Metal Termination Bars: Aluminum bars, approximately 1 by 1/8 inch, predrilled at 9-inch centers.
- G. Protection Course: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:
 - 1. Thickness: Nominal 1/8 inch for vertical applications; 1/4 inch elsewhere.
 - 2. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for protection course type.
- H. Protection Course: Fan folded, with a core of extruded-polystyrene board insulation faced on one side with plastic film, nominal thickness 1/4 inch, with compressive strength of not less than 8 psi per ASTM D 1621, and maximum water absorption by volume of 0.6 percent per ASTM C 272/C 272M.

2.3 MOLDED-SHEET DRAINAGE PANELS

- A. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel with Polymeric Film: Composite subsurface drainage panel acceptable to waterproofing manufacturer and consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 sieve laminated to one side of the core and a polymeric film bonded to the other side; and with a vertical flow rate through the core of 9 to 21 gpm per ft..
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. American Hydrotech, Inc.
 - b. BASF Corp. - Construction Chemicals.
 - c. Carlisle Coatings & Waterproofing Inc.
 - d. CETCO, a Minerals Technologies company.

2.4 INSULATION DRAINAGE PANELS

- A. Geotextile-Faced, Plaza-Deck Insulation Type VII, Drainage Panels: Extruded-polystyrene board insulation according to ASTM C 578, Type VII, 60-psi minimum compressive strength; fabricated with tongue-and-groove edges, with one side having grooved drainage channels, and faced with manufacturer's standard, nonwoven geotextile filter fabric.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean, prepare, and treat substrates according to manufacturer's written instructions. Provide clean, dust-free, and dry substrates for waterproofing application.
- B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.

3.2 MODIFIED BITUMINOUS SHEET-WATERPROOFING APPLICATION

- A. Install modified bituminous sheets according to waterproofing manufacturer's written instructions and per recommendations in ASTM D 6135.
- B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours.
- C. Apply and firmly adhere sheets over area to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2-inch- minimum lap widths and end laps. Overlap and seal seams, and stagger end laps to ensure watertight installation.
 - 1. When ambient and substrate temperatures range between 25 and 40 deg F, install self-adhering, modified bituminous sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60 deg F.
- D. Horizontal Application: Apply sheets from low to high points of decks to ensure that laps shed water.
- E. Apply continuous sheets over already-installed sheet strips, bridging substrate cracks, construction, and contraction joints.
- F. Seal edges of sheet-waterproofing terminations with mastic.
- G. Install sheet-waterproofing and auxiliary materials to tie into adjacent waterproofing.
- H. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fish mouths and blisters. Patch with sheet waterproofing extending 6 inches beyond repaired areas in all directions.
- I. Immediately install protection course with butted joints over waterproofing membrane.
 - 1. Molded-sheet drainage panels may be used in place of a separate protection course to vertical applications when approved by waterproofing manufacturer and installed immediately.

3.3 MOLDED-SHEET DRAINAGE-PANEL INSTALLATION

- A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, according to manufacturer's written instructions. Use adhesive or another method that does not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
 - 1. For vertical applications, install protection course before installing drainage panels.

3.4 INSULATION DRAINAGE-PANEL INSTALLATION

- A. Install insulation drainage panels over waterproofed surfaces. Cut and fit to within 3/4 inch of projections and penetrations.
- B. Ensure that drainage channels are aligned and free of obstructions.
- C. On vertical surfaces, set insulation drainage panels in adhesive or tape applied according to manufacturer's written instructions.
- D. On horizontal surfaces, loosely lay insulation drainage panels according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

3.5 PROTECTION, REPAIR, AND CLEANING

- A. Do not permit foot or vehicular traffic on unprotected membrane.
- B. Protect installed insulation drainage panels from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
- C. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.

Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended in writing by manufacturer of affected construction.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 07 13 26

SECTION 07 21 00 - THERMAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Glass-fiber blanket insulation.
- B. Related Requirements:
 - 1. Section 061600 "Sheathing" for foam-plastic board sheathing installed directly over wood or steel framing.
 - 2. Section 075419 "Polyvinyl-Chloride (PVC) Roofing" for insulation specified as part of roofing construction.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Glass-fiber blanket insulation.
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. Product Data: For adhesives, indicating VOC content.
 - 3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 4. Laboratory Test Reports: For Insulation, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

- A. Installer's Certification: Listing type, manufacturer, and R-value of insulation installed in each element of the building thermal envelope.
 - 1. Sign, date, and post the certification in a conspicuous location on Project site.
- B. Product Test Reports: For each product, for tests performed by a qualified testing agency.
- C. Research Reports: For foam-plastic insulation, from ICC-ES.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.
- B. Protect foam-plastic board insulation as follows:
 - 1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
 - 2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site until just before installation time.
 - 3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 - PRODUCTS

2.1 GLASS-FIBER BLANKET INSULATION

- A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- B. Glass-Fiber Blanket Insulation, Unfaced: ASTM C665, Type I; passing ASTM E136 for combustion characteristics.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed Insulation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Owens Corning.
 - 2. Flame-Spread Index: Not more than 25 when tested in accordance with ASTM E84.
 - 3. Smoke-Developed Index: Not more than 50 when tested in accordance with ASTM E84.
 - 4. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.
- C. Glass-Fiber Blanket Insulation, Polypropylene-Scrim-Kraft Faced: ASTM C665, Type II (nonreflective faced), Class A (faced surface with a flame-spread index of 25 or less); Category 1 (membrane is a vapor barrier).
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed Insulation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Owens Corning.

2. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.

2.2 INSULATION FASTENERS

- A. Adhesively Attached, Spindle-Type Anchors: Plate welded to projecting spindle; capable of holding insulation of specified thickness securely in position with self-locking washer in place.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. AGM Industries, Inc.
 - b. Gemco.
 2. Plate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.762 mm) thick by 2 inches (50 mm) square.
 3. Spindle: Copper-coated, low-carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation.
- B. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized-steel sheet, with beveled edge for increased stiffness, sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) square or in diameter.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. AGM Industries, Inc.
 - b. Gemco.
 2. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in the following locations:
- C. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates without damaging insulation, fasteners, or substrates.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. AGM Industries, Inc.
 - b. Gemco.

2.3 ACCESSORIES

- A. Insulation for Miscellaneous Voids:
 1. Glass-Fiber Insulation: ASTM C764, Type II, loose fill; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E84.

2. Spray Polyurethane Foam Insulation: ASTM C1029, Type II, closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E84.
- B. Adhesive for Bonding Insulation: Product compatible with insulation and air and water barrier materials, and with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.
 1. Adhesives shall have a VOC content of 70 g/L or less.
- C. Eave Ventilation Troughs: Preformed, rigid fiberboard or plastic sheets designed and sized to fit between roof framing members and to provide ventilation between insulated attic spaces and vented eaves.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean substrates of substances that are harmful to insulation, including removing projections capable of puncturing insulation or vapor retarders, or that interfere with insulation attachment.

3.2 INSTALLATION, GENERAL

- A. Comply with insulation manufacturer's written instructions applicable to products and applications.
- B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.
- C. Install insulation with manufacturer's R-value label exposed after insulation is installed.
- D. Extend insulation to envelop entire area to be insulated. Fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.
- E. Provide sizes to fit applications and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units unless multiple layers are otherwise shown or required to make up total thickness or to achieve R-value.

3.3 INSTALLATION OF SLAB INSULATION

- A. On vertical slab edge and foundation surfaces, set insulation units using manufacturer's recommended adhesive according to manufacturer's written instructions.
 1. If not otherwise indicated, extend insulation a minimum of 24 inches (610 mm) below exterior grade line.
- B. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.
 1. If not otherwise indicated, extend insulation a minimum of 60 inches (1524 mm) in from exterior walls.

3.4 INSTALLATION OF FOUNDATION WALL INSULATION

- A. Butt panels together for tight fit.
- B. Anchor Installation: Install board insulation on concrete substrates by adhesively attached, spindle-type insulation anchors as follows:
 - 1. Fasten insulation anchors to concrete substrates with insulation anchor adhesive according to anchor manufacturer's written instructions.
 - 2. Space anchors according to insulation manufacturer's written instructions for insulation type, thickness, and application.
 - 3. Apply insulation standoffs to each spindle to create cavity width indicated on Drawings between concrete substrate and insulation.
 - 4. After adhesive has dried, install board insulation by pressing insulation into position over spindles and securing it tightly in place with insulation-retaining washers, taking care not to compress insulation.
 - 5. Where insulation will not be covered by other building materials, apply capped washers to tips of spindles.
- C. Adhesive Installation: Install with adhesive or press into tacky waterproofing or dampproofing according to manufacturer's written instructions.

3.5 INSTALLATION OF CAVITY-WALL INSULATION

- A. Foam-Plastic Board Insulation: Install pads of adhesive spaced approximately 24 inches (610 mm) o.c. both ways on inside face and as recommended by manufacturer.
 - 1. Fit courses of insulation between wall ties and other obstructions, with edges butted tightly in both directions, and with faces flush.
 - 2. Press units firmly against inside substrates.
 - 3. Supplement adhesive attachment of insulation by securing boards with two-piece wall ties designed for this purpose and specified in Section 042000 "Unit Masonry."

3.6 INSTALLATION OF INSULATION IN FRAMED CONSTRUCTION

- A. Blanket Insulation: Install in cavities formed by framing members according to the following requirements:
 - 1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill the cavities, provide lengths that will produce a snug fit between ends.
 - 2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
 - 3. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.
 - 4. Attics: Install eave ventilation troughs between roof framing members in insulated attic spaces at vented eaves.
 - 5. For metal-framed wall cavities where cavity heights exceed 96 inches (2438 mm), support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.

6. Vapor-Retarder-Faced Blankets: Tape joints and ruptures in vapor-retarder facings, and seal each continuous area of insulation to ensure airtight installation.
 - a. Exterior Walls: Set units with facing placed toward interior of construction.
 - B. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation using the following materials:
 1. Glass-Fiber Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft. (40 kg/cu. m).
 2. Spray Polyurethane Insulation: Apply according to manufacturer's written instructions.
- 3.7 PROTECTION
- A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes.
 - B. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 07 21 00

SECTION 07 27 26 - FLUID APPLIED MEMBRANE AIR BARRIERS

PART - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vapor-permeable, fluid-applied air barriers.
2. Rainscreen drainage mat for use over fluid-applied air barriers applied to wall construction.

B. Related Requirements:

1. Section 061600 "Sheathing" for wall sheathings.

1.3 DEFINITIONS

- A. Air-Barrier Material: A primary element that provides a continuous barrier to the movement of air.
- B. Air-Barrier Accessory: A transitional component of the air barrier that provides continuity.
- C. Air-Barrier Assembly: The collection of air-barrier materials and accessories applied to an opaque wall, including joints and junctions to abutting construction, to control air movement through the wall.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include manufacturer's written instructions for evaluating, preparing, and treating each substrate; technical data; dry film thickness; and tested physical and performance properties of products.

B. Shop Drawings: For air-barrier assemblies.

1. Show locations and extent of air-barrier materials, accessories, and assemblies specific to Project conditions.
2. Include details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.
3. Include details of interfaces with other materials that form part of air barrier.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Certificates: From air-barrier manufacturer, certifying compatibility of air barriers and accessory materials with Project materials that connect to or that come in contact with the barrier.
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Remove and replace liquid materials that cannot be applied within their stated shelf life.
- B. Protect stored materials from direct sunlight.

1.8 FIELD CONDITIONS

- A. Environmental Limitations: Apply air barrier within the range of ambient and substrate temperatures recommended in writing by air-barrier manufacturer.
 - 1. Protect substrates from environmental conditions that affect air-barrier performance.
 - 2. Do not apply air barrier to a damp or wet substrate or during snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Source Limitations: Obtain primary air-barrier materials and air-barrier accessories from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Air-Barrier Performance: Air-barrier assembly and seals with adjacent construction shall be capable of performing as a continuous air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies shall be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.
- B. Air-Barrier Assembly Air Leakage: Maximum 0.04 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft., when tested according to ASTM E2357.

2.3 MEDIUM-BUILD AIR BARRIERS, VAPOR PERMEABLE

A. Medium-Build, Vapor-Permeable Air Barrier: Synthetic polymer material with an installed dry film thickness, according to manufacturer's written instructions, of 17 to 30 mils over smooth, void-free substrates.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. DuPont Safety and Construction.
 - b. GCP Applied Technologies Inc.
 - c. Henry.
 - d. Sto Corp.
 - e. W.R. Meadows, Inc.
2. Physical and Performance Properties:
 - a. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. pressure difference; ASTM E2178.
 - b. Vapor Permeance: Minimum 12 perms; ASTM E96/E96M, Desiccant Method, Procedure A.
 - c. Ultimate Elongation: Minimum 250 percent; ASTM D412, Die C.
 - d. Adhesion to Substrate: Minimum 16 lbf/sq. in when tested according to ASTM D4541.
 - e. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.
 - f. UV Resistance: Can be exposed to sunlight for 90 days according to manufacturer's written instructions.

2.4 RAINSCREEN DRAINAGE MAT

A. Drainage Mat: Non-compressible drainage and ventilation mat designed to eliminate moisture and moisture vapor in above grade wall applications.

1. Physical Characteristics: Three-dimensional mat bonded to a non-woven vapor permeable fabric.
 - a. Thickness: 1/4 inch.
 - b. Flame Spread: ASTM E84 Class A.
 - c. Core Material: Polymer matrix.
 - 1) UV stabilized.
 - 2) Hydrophobic compound.
 - 3) Resistant to chemicals.
 - 4) Does not support mold growth.
- Fabric Material: Non-woven UV stabilized polypropylene fiber.

2.5 ACCESSORY MATERIALS

- A. Requirement: Provide primers, transition strips, termination strips, joint reinforcing fabric and strips, joint sealants, counterflashing strips, flashing sheets and metal termination bars, termination mastic, substrate patching materials, adhesives, tapes, foam sealants, lap sealants, and other accessory materials that are recommended in writing by air-barrier manufacturer to produce a complete air-barrier assembly and that are compatible with primary air-barrier material and adjacent construction to which they may seal.
- B. Primer: Liquid waterborne or solvent-borne primer recommended for substrate by air-barrier material manufacturer.
- C. Stainless-Steel Sheet: ASTM A240/A240M, Type 304, 0.0250 inch thick, and Series 300 stainless-steel fasteners.
- D. Preformed Silicone Extrusion: Manufacturer's standard system consisting of cured low-modulus silicone extrusion, sized to fit opening widths, with a single-component, neutral-curing, Class 100/50 (low-modulus) silicone sealant for bonding extrusions to substrates.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. GE Construction Sealants; Momentive Performance Materials Inc.
 - b. Pecora Corporation.
 - c. The Dow Chemical Company.
 - d. Tremco Incorporated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
 - 1. Verify that substrates are sound and free of oil, grease, dirt, excess mortar, or other contaminants.
 - 2. Verify that substrates have cured and aged for minimum time recommended in writing by air-barrier manufacturer.
 - 3. Verify that substrates are visibly dry and free of moisture.
 - 4. Verify that masonry joints are flush and completely filled with mortar.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SURFACE PREPARATION

- A. Clean, prepare, treat, fill, and seal substrate and joints and cracks in substrate according to manufacturer's written instructions and details. Provide clean, dust-free, and dry substrate for air-barrier application.

- B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.
- C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
- D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching material.
- E. Remove excess mortar from masonry ties, shelf angles, and other obstructions.
- F. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.
- G. Cover gaps in substrate plane and form a smooth transition from one substrate plane to another with stainless-steel sheet mechanically fastened to structural framing to provide continuous support for air barrier.
- H. Bridge isolation joints, expansion joints, discontinuous wall-to-wall, deck-to-wall, and deck-to-deck joints with air-barrier accessory material that accommodates joint movement according to manufacturer's written instructions and details.

3.3 ACCESSORIES INSTALLATION

- A. Install accessory materials according to air-barrier manufacturer's written instructions and details to form a seal with adjacent construction and ensure continuity of air and water barrier.
 - 1. Coordinate the installation of air barrier with installation of roofing membrane and base flashing to ensure continuity of air barrier with roofing membrane.
 - 2. Install transition strip on roofing membrane or base flashing so that a minimum of 3 inches of coverage is achieved over each substrate.
 - 3. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.
 - 4. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by air-barrier material on same day. Reprime areas exposed for more than 24 hours.
- B. Connect and seal exterior wall air-barrier material continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials.
- C. At end of each working day, seal top edge of strips and transition strips to substrate with termination mastic.
- D. Apply joint sealants forming part of air-barrier assembly within manufacturer's recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.

- E. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Apply transition strip so that a minimum of 3 inches of coverage is achieved over each substrate. Maintain 3 inches of full contact over firm bearing to perimeter frames, with not less than 1 inch of full contact.
- F. Transition Strip: Roll firmly to enhance adhesion.
- G. Fill gaps in perimeter frame surfaces of windows, curtain walls, storefronts, and doors, and miscellaneous penetrations of air-barrier material with foam sealant.
- H. Seal top of through-wall flashings to air barrier with an additional 6-inch- wide, transition strip.
- I. Seal exposed edges of strips at seams, cuts, penetrations, and terminations not concealed by metal counterflashings or ending in reglets with termination mastic.
- J. Repair punctures, voids, and deficient lapped seams in strips and transition strips. Slit and flatten fishmouths and blisters. Patch with transition strips extending 6 inches beyond repaired areas in strip direction.

3.4 PRIMARY AIR-BARRIER MATERIAL INSTALLATION

- A. Apply air-barrier material to form a seal with strips and transition strips and to achieve a continuous air barrier according to air-barrier manufacturer's written instructions and details. Apply air-barrier material within manufacturer's recommended application temperature ranges.
 - 1. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.
 - 2. Limit priming to areas that will be covered by air-barrier material on same day. Reprime areas exposed for more than 24 hours.
 - 3. Where multiple prime coats are needed to achieve required bond, allow adequate drying time between coats.
- B. Medium-Build Air Barriers: Apply continuous unbroken air-barrier material to substrates according to the following thickness. Apply an increased thickness of air-barrier material in full contact around protrusions such as masonry ties.
 - 1. Vapor-Permeable, Medium-Build Air Barrier: Total dry film thickness as recommended in writing by manufacturer to comply with performance requirements, applied in **one or** more equal coats. Apply additional material as needed to achieve void- and pinhole-free surface, but do not exceed thickness on which required vapor permeability is based.
- C. Do not cover air barrier until it has been tested and inspected by testing agency.
- D. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

3.5 RAINSCREEN DRAINAGE MAT

- A. Install in accordance with manufacturer's written instructions.

- B. Maximum exposure to not exceed 30 days prior to cladding installation.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform inspections.
- B. Inspections: Air-barrier materials, accessories, and installation are subject to inspection for compliance with requirements. Inspections may include the following:
 - 1. Continuity of air-barrier system has been achieved throughout the building envelope with no gaps or holes.
 - 2. Air-barrier dry film thickness.
 - 3. Continuous structural support of air-barrier system has been provided.
 - 4. Masonry and concrete surfaces are smooth, clean, and free of cavities, protrusions, and mortar droppings.
 - 5. Site conditions for application temperature and dryness of substrates have been maintained.
 - 6. Maximum exposure time of materials to UV deterioration has not been exceeded.
 - 7. Surfaces have been primed, if applicable.
 - 8. Laps in strips and transition strips have complied with minimum requirements and have been shingled in the correct direction (or mastic has been applied on exposed edges), with no fishmouths.
 - 9. Termination mastic has been applied on cut edges.
 - 10. Strips and transition strips have been firmly adhered to substrate.
 - 11. Compatible materials have been used.
 - 12. Transitions at changes in direction and structural support at gaps have been provided.
 - 13. Connections between assemblies (air-barrier and sealants) have complied with requirements for cleanliness, surface preparation and priming, structural support, integrity, and continuity of seal.
 - 14. All penetrations have been sealed.
- C. Air barriers will be considered defective if they do not pass inspections.
 - 1. Apply additional air-barrier material, according to manufacturer's written instructions, where inspection results indicate insufficient thickness.
 - 2. Remove and replace deficient air-barrier components for retesting as specified above.
- D. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.
- E. Prepare inspection reports.

3.7 CLEANING AND PROTECTION

- A. Protect air-barrier system from damage during application and remainder of construction period, according to manufacturer's written instructions.
 - 1. Protect air barrier from exposure to UV light and harmful weather exposure as recommended in writing by manufacturer. If exposed to these conditions for longer than recommended, remove and replace air barrier or install additional, full-thickness, air-

- barrier application after repairing and preparing the overexposed materials according to air-barrier manufacturer's written instructions.
 - 2. Protect air barrier from contact with incompatible materials and sealants not approved by air-barrier manufacturer.
- B. Clean spills, stains, and soiling from construction that would be exposed in the completed work using cleaning agents and procedures recommended in writing by manufacturer of affected construction.
- C. Remove masking materials after installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 07 27 26

SECTION 07 41 13.16 - STANDING-SEAM METAL ROOF PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes standing-seam metal roof panels and accessories for standing-seam metal roof panels including gutters, downspouts, snow guards, trim, underlayment materials, and roof insulation.
- B. Related Sections:
 - 1. Section 07 62 00 "Sheet Metal Flashing and Trim"

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Meet with Owner, Architect, Owner's insurer if applicable, metal panel Installer, metal panel manufacturer's representative and installers whose work interfaces with or affects metal panels, including installers of roof accessories and roof-mounted equipment.
 - 2. Review methods and procedures related to metal panel installation, including manufacturer's written instructions.
 - 3. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.
 - 4. Review flashings, special details, drainage, penetrations, equipment curbs, and condition of other construction that affect metal panels.
 - 5. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
 - 6. Review procedures for repair of metal panels damaged after installation.
 - 7. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of roof panel, underlayment, snow guard, insulation, and accessory.

B. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
2. Accessories: Include details of the flashing, trim, and anchorage systems, at a scale of not less than 1-1/2 inches per 12 inches

C. Samples for Initial Selection: For each exposed product specified, including sealants, provide representative color charts of manufacturer's full range of colors.

D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.

1. Metal Panels: 12 inches long by actual panel width. Provide color chip verifying color selection.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each product, indicating compliance of products with requirements.

1. For each type of snow guard tests performed by a qualified testing agency indicating load at failure of attachment to roof system identical to roof system used on this Project.

C. Sample Warranties: For standard warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panels to include in maintenance manuals.

B. Manufacturer's Warranty: Executed copy of manufacturer's standard warranty.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Minimum five years of experience in manufacture of similar products in successful use in similar applications.

B. Installer Qualifications: Experienced installer, certified by metal panel manufacturer, with minimum five of years of experience with successfully completed projects of a similar nature and scope.

C. Field Supervisor Qualifications: Experienced mechanic, certified by metal panel manufacturer, supervising work whenever work is underway.

1.8 PERFORMANCE REQUIREMENTS

A. Snow Guards:

1. Provide snow guards that withstand exposure to weather and resist thermally induced movement without failure, rattling, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
 - a. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
2. Structural Performance: Snow guards shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.
 - a. Snow Loads: As indicated on Drawings.
 - b. Design snow guards, including attachment to roofing material, based on the following:
 - 1) Roof snow load.
 - 2) Snow drifting
 - 3) Roof slope.
 - 4) Roof type.
 - 5) Roof dimensions.
 - 6) Roofing substrate type and thickness.
 - 7) Snow guard type.
 - 8) Snow guard fastening method and strength.
 - 9) Snow guard spacing.
 - 10) Coefficient of Friction Between Snow and Roof Surface: 0.
 - 11) Factor of Safety: 3.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.
- B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.
- C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.
- D. Retain strippable protective covering on metal panels during installation.

1.10 FIELD CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed in accordance with manufacturers' written instructions and warranty requirements.

1.11 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.
- B. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.12 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including rupturing, cracking, or puncturing.
 - b. Deterioration of metals and other materials beyond normal weathering.
 - 2. Warranty Period: Five years from date of Substantial Completion.
- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - a. Two-Coat Fluoropolymer:
 - 1) Color fading more than 5 Hunter units when tested in accordance with ASTM D2244.
 - 2) Chalking in excess of a No. 8 when tested in accordance with ASTM D4214.
 - 3) Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Finish Warranty Period: Minimum 25 years from date of Substantial Completion.
- C. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that fail to remain weathertight, including leaks, up to cost limitation of \$7.00 per square foot of covered area within specified warranty period.
 - 1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

- A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing in accordance with ASTM E1592:
 - 1. Wind Loads: As indicated on Drawings.
 - 2. Other Design Loads: As indicated on Drawings.
 - 3. Deflection Limits: For wind loads, no greater than 1/180 of the span.
- B. Air Infiltration: Maximum 0.013 cfm/sq. ft. at static-air-pressure difference of 6.24 lbf/sq. ft. not more than 0.020 cfm/sq. ft. when tested in accordance with ASTM E1680.
- C. Water Penetration under Static Pressure: No water penetration when tested in accordance with ASTM E1646 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 12.00 lbf/sq. ft.
- D. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance class indicated.
 - 1. Uplift Rating: UL 90.
- E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

2.2 STANDING-SEAM METAL ROOF PANELS

- A. General: Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips, cleats, pressure plates, and accessories required for weathertight installation.
 - 1. Steel Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E1514.
- B. Source Limitations: Obtain metal roof panel assembly and accessories from a single source with resources to provide fixed base roll forming, and accredited under IAS AC 472 Part B.
- C. Trapezoidal-Rib, Seamed-Joint, Standing-Seam Metal Roof Panels: Formed with raised trapezoidal ribs at panel edges and smooth with minor ribs in pan between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels, engaging opposite edge of adjacent panels, and mechanically seaming panels together.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide MBCI; Double-Lok® (DLMSMBCI) or comparable product by one of the following:

- a. Exceptional Metals.
 - b. Bridger Steel.
 - c. McElroy Metal, Inc.
 - d. Other manufacturer complying with requirements.
2. Metallic-Coated Steel Sheet: Aluminum-zinc alloy-coated steel sheet complying with ASTM A792/A792M, Class AZ50 coating designation; structural quality, prepainted by the coil-coating process to comply with ASTM A755/A755M.
 - a. Nominal Thickness: 22 gage coated thickness.
 - b. Exterior Finish: Two-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
3. Two Piece Floating Clips: ASTM C 645, with ASTM A 653/A 653M, G90 (Z180) hot-dip galvanized zinc coating, configured for concealment in panel joints, and identical to clips utilized in tests demonstrating compliance with performance requirements.
4. Joint Type: Double folded.
5. Panel Coverage: 18 inches.
6. Panel Height: 3.0 inches

2.3 UNDERLAYMENT MATERIALS

- A. Self-Adhering, High-Temperature Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 30 mils thick, consisting of slip-resistant, polyethylene-film top surface laminated to a layer of butyl or SBS-modified asphalt adhesive, with release-paper backing. Provide primer when recommended by underlayment manufacturer.
 1. Thermal Stability: Stable after testing at 240 deg F; ASTM D1970.
 2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F; ASTM D1970.
 3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. GCP Applied Technologies Inc.
 - b. Henry Company.
 - c. Carlisle Residential; a division of Carlisle Construction Materials.
 - d. Drexel Metals.
 - e. Kirsch Building Products, LLC.
 - f. Owens Corning.
- B. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.

2.4 ROOF INSULATION

- A. General: Preformed roof insulation boards approved by standing-seam metal roof panel manufacturer.

- B. Composite Polyisocyanurate Board Insulation: ASTM C1289, Type V, Class 1, Grade 3 with factory-applied facing board on one major surface, as indicated below by type, and felt or glass-fiber mat facer on the other.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Rmax.
 - b. Hunter Panels.
 - c. GAF.
 - d. Atlas Roofing Corporation.
 - 2. Compressive Strength: 25 psi.
 - 3. Facer: Type V, oriented strand board facer, 7/16 inch thick.
 - 4. Size: 48 by 96 inches.
 - 5. Total thickness including Facer: 2 1/2 inches.
- A. Polyisocyanurate Board Insulation: ASTM C1289, Type II, Class 1, Grade 3, felt or glass-fiber mat facer on both major surfaces.
 - 1. Manufacturers: Subject to compliance with requirements, provide insulation from the manufacturer furnishing the composite polyisocyanurate board insulation.
 - 2. Compressive Strength: 25 psi.
 - 3. Size: 48 by 96 inches.
 - 4. Thickness: 2 inches.

2.5 VAPOR RETARDER

- A. Polyethylene Film: ASTM D4397, 6 mils thick, minimum, with maximum permeance rating of 0.76 perm.
 - 1. Tape: Pressure-sensitive tape of type recommended by vapor retarder manufacturer for sealing joints and penetrations in vapor retarder.

2.6 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Subframing and Furring: ASTM C645; cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G60 coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, corner units, clips, flashings, sealants, gaskets, fillers, closures, and similar items. Match material and finish of metal panels unless otherwise indicated.
 - 1. Closures: Provide inside closures at eaves and outside closures at ridges, fabricated of same metal as metal panels.
 - 2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.

- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.
- D. Gutters: Formed from same material as roof panels, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 122-inch-long sections, of size and metal thickness in accordance with SMACNA's "Architectural Sheet Metal Manual." Furnish gutter supports spaced a maximum of 36 inches o.c., fabricated from same metal as gutters. Provide wire ball strainers of compatible metal at outlets. Finish gutters to match roof fascia and rake trim. Size as indicated in the drawings.
- E. Downspouts: Plain rectangular complete with mitered elbows formed from same material as roof panels. Fabricate in 10-foot-long sections, complete with formed elbows and offsets, of size and metal thickness in accordance with SMACNA's "Architectural Sheet Metal Manual." Furnish with metal hangers, from same material as downspouts, and anchors. Size as indicated in the drawings.
 - a. Nominal Minimum Thickness: 22 gage coated thickness.
 - b. Exterior Finish: Two-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
- F. Panel Fasteners: Self-tapping screws and other acceptable corrosion-resistant fasteners recommended by manufacturer. Where exposed fasteners cannot be avoided, supply fasteners with EPDM or neoprene gaskets, with heads matching color of metal panels by means of factory-applied coatings, designed to withstand design loads.
- G. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.
 - 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape.
 - 2. Joint Sealant: Manufacturer's standard or recommended liquid and preformed sealers and tapes and as follows:
 - a. Factory-Applied Seam Sealant: Manufacturer's standard hot-melt type.
 - b. Concealed Joint Sealant: Non-curing butyl, AAMA 809.2.
 - 3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.
- H. Snow Guards: Prefabricated devices designed to hold snow and ice on the roof surface, allowing it to melt and drain off slowly:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Metal Roof Innovations, Ltd. S-5! ColorGard snow retention system or comparable product by one of the following:
 - a. PMC Industries Inc.
 - b. Alpine SnowGuards, a division of Vermont Slate & Copper Services Inc.
 - c. Action Manufacturing.

2. Description: Snow retention rail clamped to standing-seam with integral track to accept color-matching insert with color and finish matching metal roof, and snow clips attached to rail between standing-seams.
 - a. Seam Clamps: Mill finished or clear anodized aluminum, or stainless steel.
 - b. Rails: Mill finish or clear anodized aluminum, or stainless steel.
 - c. Snow Clips: Mill finish or clear anodized extruded aluminum.
 - d. Color-matching Insert: Aluminum with exposed face matching color and finish of metal roof.
 - e. Fasteners: Stainless steel.

2.7 FABRICATION

- A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
- B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- C. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.
 1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
 2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
 3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 4. Sealed Joints: Form non-expansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
 5. Conceal fasteners and expansion provisions where possible.
 6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.
 - a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal panel manufacturer for application, but not less than thickness of metal being secured.

2.8 FINISHES

- A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in

same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Steel Panels and Accessories:

1. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.
 1. Examine primary and secondary roof framing to verify that rafters, purlins, angles, channels, and other structural panel support members and anchorages have been installed within alignment tolerances required by metal roof panel manufacturer.
 2. Examine solid roof sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal roof panel manufacturer.
 - a. Verify that air- or water-resistive barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.
- B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages in accordance with ASTM C754 and metal panel manufacturer's written recommendations.

3.3 INSTALLATION OF VAPOR RETARDER

- A. Polyethylene Film: Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2 and 6 inches, respectively.

1. Extend vertically up parapet walls and projections to a minimum height equal to height of the insulation and cover board.
2. Continuously seal side and end laps with tape.

3.4 INSULATION INSTALLATION

- A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at end of workday.
- B. Comply with roofing system and insulation manufacturer's written instructions for installing roof insulation.
- C. Installation Over Metal Decking:
 1. Install base layer of insulation with end joints staggered not less than 12 inches in adjacent rows and with long joints continuous at right angle to flutes of decking.
 - a. Locate end joints over crests of decking.
 - b. Where installing composite and noncomposite insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
 - c. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 - d. Make joints between adjacent insulation boards not more than recommended by manufacturer or 1/4 inch in width whichever is less.
 - e. Make joints between adjacent composite polyisocyanurate board insulation OSB facers not less than 1/8 inch in width.
 - f. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.
 - g. Mechanically attach insulation using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to metal decks.
 - 1) Fasten insulation to resist specified uplift pressure at corners, perimeter, and field of roof.

3.5 UNDERLAYMENT INSTALLATION

- A. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply to entire roof surface and at locations indicated on Drawings and locations recommended by standing-seam metal roof panel manufacturer, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps with roller. Cover underlayment within 14 days.
- B. Slip Sheet: Apply slip sheet over underlayment before installing metal roof panels if recommended by standing-seam metal roof panel manufacturer.
- C. Flashings: Install flashings to cover underlayment to comply with requirements specified in Section 07 62 00 "Sheet Metal Flashing and Trim."

3.6 METAL PANEL INSTALLATION

- A. General: Install metal panels in accordance with manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.
1. Install panels symmetrically between rakes, parapets, or wall faces as applicable with end panels equal in width. Align either the seam or the centerline of a panel with the centerline of the roof to produce the largest width equal size panels at the rakes, abutting parapets or wall faces.
 2. Where a roof changes in slope and pitch transition flashing is provided between adjacent lower and upper roof panels align panel seams of adjacent sections of roof.
 3. Shim or otherwise plumb substrates receiving metal panels.
 4. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.
 5. Install screw fasteners in predrilled holes.
 6. Locate and space fastenings in uniform vertical and horizontal alignment.
 7. Install flashing and trim as metal panel work proceeds.
 8. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
 9. Align bottoms of metal panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
 10. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.
- B. Fasteners:
1. Steel Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized-steel fasteners for surfaces exposed to the interior.
- C. Anchor Clips: Anchor metal roof panels and other components of the Work securely in place, using manufacturer's approved fasteners in accordance with manufacturers' written instructions.
- D. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.
- E. Standing-Seam Metal Roof Panel Installation: Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended in writing by manufacturer.
1. Install clips to supports with self-tapping fasteners.
 2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
 3. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so clip, metal roof panel, and factory-applied sealant are completely engaged.
 4. Watertight Installation:
 - a. Apply a continuous ribbon of sealant or tape to seal joints of metal panels, using sealant or tape as recommend in writing by manufacturer as needed to make panels watertight.

- b. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
 - c. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.
- F. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
 - 1. Install components required for a complete metal panel system including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal roof panel manufacturers; or, if not indicated, types recommended by metal roof panel manufacturer.
- G. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - 1. Install exposed flashing and trim that is without buckling and tool marks, and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and achieve waterproof and weather-resistant performance.
- H. Gutters: Join sections with riveted and soldered or lapped and sealed joints. Attach gutters to eave with gutter hangers spaced not more than 48 inches o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.
- I. Downspouts: Join sections with telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch away from walls; locate fasteners at top and bottom and at approximately 60 inches o.c. in between.
 - 1. Connect downspouts to underground drainage system indicated.
- J. Roof Curbs: Install flashing around bases where they meet metal roof panels.
- K. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to metal roof panels as recommended by manufacturer.

3.7 SNOW GUARD INSTALLATION

- A. Install snow guards according to manufacturer's written instructions.
 - 1. Space rows as indicated on Shop Drawings.
 - 2. Space rows as recommended by manufacturer.
- B. Attachment for Standing-Seam Metal Roofing:
 - 1. Do not use fasteners that will penetrate metal roofing or fastening methods that void metal roofing finish warranty.
 - 2. Rail-Type, Seam-Mounted Snow Guards:

- a. Install brackets to vertical ribs in straight rows.
- b. Secure with stainless steel set screws, incorporating round nonpenetrating point, on same side of standing seam.
- c. Torque set screw according to manufacturer's instructions.
- d. Install cross members to brackets.
- e. Install snow clips between panel standing-seam at spacing recommended by manufacturer. Where one clip is to be provided for each roofing panel center between standing-seams. Where more than one snow clip is to be provided for each roofing panel space such that spacing of snow clips for each adjacent roofing panel is identical. Adjust height of snow clip above roof panel surface as recommended by manufacturer.

3.8 ERECTION TOLERANCES

- A. Installation Tolerances: Shim and align metal panel units within installed tolerance of 1/4 inch in 20 feet on slope and location lines as indicated and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.9 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect metal roof panel installation, including accessories. Report results in writing.
- B. Remove and replace applications of metal roof panels where tests and inspections indicate that they do not comply with specified requirements.
- C. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.
- D. Prepare test and inspection reports.

3.10 CLEANING AND PROTECTION

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.
- B. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 07 41 13.16

SECTION 074213.13 - FORMED METAL WALL PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concealed-fastener, lap-seam metal wall panels.

1.2 RELATED DOCUMENTS

1. Section 074293 "Soffit Panels" for metal panels used in horizontal soffit applications.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
- C. Samples: For each type of metal panel indicated.

1.5 INFORMATIONAL SUBMITTALS

- A. Product test reports.
- B. Warranties: Samples of special warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: 20 years from date of Substantial Completion.

- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

- 1. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 1592:

- 1. Wind Loads: As indicated on Drawings.
 - 2. Other Design Loads: As indicated on Drawings.
 - 3. Deflection Limits: For wind loads, no greater than 1/240 of the span.

- B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E 283 at the following test-pressure difference:

- 1. Test-Pressure Difference: 1.57 lbf/sq. ft.

- C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:

- 1. Test-Pressure Difference: 2.86 lbf/sq. ft.

- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

- 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

2.2 CONCEALED-FASTENER, LAP-SEAM METAL WALL PANELS

- A. General: Provide factory-formed metal panels designed to be field assembled by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps. Include accessories required for weathertight installation.
- B. Flush-Profile, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and a flat pan between panel edges; with flush joint between panels.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Alcoa Architectural Products (USA).
 - b. CENTRIA Architectural Systems.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G90 coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M, Class AZ50 coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Nominal Thickness: 0.034 inch.
 - b. Exterior Finish: Three-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
 - 3. Panel Coverage: As shown on drawings
 - 4. Panel Height: As shown on drawings.
- C. Reveal-Joint, Concealed-Fastener Metal Wall Panels: Formed with vertical panel edges and a flat pan between panel edges; with narrow reveal joint between panels.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ATAS International, Inc.
 - b. CENTRIA Architectural Systems.
 - c. PAC-CLAD; Petersen Aluminum Corporation.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G90 coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M, Class AZ50 coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Nominal Thickness: 0.034 inch.
 - b. Exterior Finish: Three-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
 - 3. Panel Coverage: As shown on drawings.
 - 4. Panel Height: As shown on drawings.

2.3 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Subframing and Furring: ASTM C 645, cold-formed, metallic-coated steel sheet, ASTM A 653/A 653M, G90 coating designation or ASTM A 792/A 792M, Class AZ50 aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.
 - 1. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal panels.
 - 2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 - 3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.
- D. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.
- E. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.
 - 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing; 1/2 inch wide and 1/8 inch thick.
 - 2. Joint Sealant: ASTM C 920; as recommended in writing by metal panel manufacturer.
 - 3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.4 FABRICATION

- A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
- B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

- C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
- D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

2.5 FINISHES

- A. Panels and Accessories:
 - 1. Three-Coat Fluoropolymer: High performance Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
 - 2. Concealed Finish: White or light-colored acrylic or polyester backer finish.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.2 METAL PANEL INSTALLATION

- A. Lap-Seam Metal Panels: Fasten metal panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.
 - 1. Lap ribbed or fluted sheets one full rib. Apply panels and associated items true to line for neat and weathertight enclosure.
 - 2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal panels.
 - 3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 - 4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
 - 5. Flash and seal panels with weather closures at perimeter of all openings.
- B. Watertight Installation:
 - 1. Apply a continuous ribbon of sealant or tape to seal lapped joints of metal panels, using sealant or tape as recommend by manufacturer on side laps of nesting-type panels; and elsewhere as needed to make panels watertight.
 - 2. Provide sealant or tape between panels and protruding equipment, vents, and accessories.

3. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.
- C. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
- D. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that are permanently watertight.

3.3 CLEANING

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 074213.13

SECTION 07 42 93 - SOFFIT PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes metal soffit panels.
- B. Related Sections:
 - 1. Section 074213.13 "Formed Metal Wall Panels" for lap-seam metal wall panels.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.
- B. Shop Drawings:
 - 1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
 - 2. Accessories: Include details of flashing, trim, and anchorage systems, at a scale of not less than 1-1/2 inches per 12 inches
- C. Samples for Initial Selection: For each type of metal panel indicated with factory-applied color finishes.
 - 1. Include similar Samples of trim and accessories involving color selection.
- D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below:
 - 1. Metal Panels: 12 inches long by actual panel width. Include fasteners, closures, and other metal panel accessories.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Test Reports: For each product, tests performed by a qualified testing agency.
- C. Sample Warranties: For special warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For metal panels to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
- B. UL-Certified, Portable Roll-Forming Equipment: UL-certified, portable roll-forming equipment capable of producing metal panels warranted by manufacturer to be the same as factory-formed products. Maintain UL certification of portable roll-forming equipment for duration of work.
- C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 - 1. Build mockup of typical roof eave, including fascia, and soffit as shown on Drawings; approximately four panels wide by full eave width, including attachments and accessories.
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.
- B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.
- C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.
- D. Retain strippable protective covering on metal panels during installation.
- E. Copper Panels: Wear gloves when handling to prevent fingerprints and soiling of surface.

1.9 FIELD CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.10 COORDINATION

- A. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of walls, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

- 1. Failures include, but are not limited to, the following:

- a. Structural failures including rupturing, cracking, or puncturing.
 - b. Deterioration of metals and other materials beyond normal weathering.

- 2. Warranty Period: Two years from date of Substantial Completion.

- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

- 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

- a. Color fading more than 5 Hunter units when tested according to ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

- 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:

- 1. Wind Loads: As indicated on Drawings.
 - 2. Other Design Loads: As indicated on Drawings.
 - 3. Deflection Limits: For wind loads, no greater than 1/240 of the span.

- B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E283 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 1.57 lbf/sq. ft.
- C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E331 at the following test-pressure difference:
 - 1. Test-Pressure Difference: 2.86 lbf/sq. ft.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): **120 deg F, ambient; 180 deg F**, material surfaces.

2.2 METAL SOFFIT PANELS

- A. General: Provide metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners inside laps. Include accessories required for weathertight installation.
- B. Metal Soffit Panels: Match profile and material of metal wall panels.
 - 1. Finish: Match finish and color of metal wall panels.
 - 2. Sealant: Factory applied within interlocking joint.
- C. Flush-Profile Metal Soffit Panels Solid panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges; with flush joint between panels.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ATAS International, Inc.
 - b. CENTRIA Architectural Systems.
 - c. MBCI.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A653/A653M, G90 coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A792/A792M, Class AZ50 coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M.
 - a. Nominal Thickness: 24 gauge
 - b. Exterior Finish: Three-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
 - 3. Aluminum Sheet: Coil-coated sheet, ASTM B209 alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.

- a. Thickness: 24 gauge
 - b. Surface: Smooth, flat finish.
 - c. Exterior Finish: Three-coat fluoropolymer.
 - d. Color: As selected by Architect from manufacturer's full range.
4. Panel Coverage: 20 inches.
5. Panel Height: 1.0 inch

2.3 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Subframing and Furring: ASTM C645, cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 coating designation or ASTM A792/A792M, Class AZ50 aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.
 1. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Finish flashing and trim with same finish system as adjacent metal panels.
- D. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.
- E. Panel Sealants: Provide sealant types recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.
 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.
 2. Joint Sealant: ASTM C920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended in writing by metal panel manufacturer.
 3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.

2.4 FABRICATION

- A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

- B. On-Site Fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.
- C. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- D. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
- E. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.
 - 1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
 - 2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
 - 3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 - 4. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
 - 5. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
 - 6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.
 - a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal soffit panel manufacturer for application but not less than thickness of metal being secured.

2.5 FINISHES

- A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- C. Steel Panels and Accessories:
 - 1. Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and

- apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.
- D. Aluminum Panels and Accessories:
1. Three-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.
1. Examine framing to verify that girts, angles, channels, studs, and other structural panel support members and anchorage have been installed within alignment tolerances required by metal panel manufacturer.
 2. Examine sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal panel manufacturer.
 - a. Verify that air- or water-resistive barriers been installed over sheathing or backing substrate to prevent air infiltration or water penetration.
- B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.
1. Soffit Framing: Wire tie or clip furring channels to supports, as required to comply with requirements for assemblies indicated].

3.3 METAL PANEL INSTALLATION

- A. General: Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated.

Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Shim or otherwise plumb substrates receiving metal panels.
2. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.
3. Install screw fasteners in predrilled holes.
4. Locate and space fastenings in uniform vertical and horizontal alignment.
5. Install flashing and trim as metal panel work proceeds.
6. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
7. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners:

1. Steel Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized-steel fasteners for surfaces exposed to the interior.
2. Aluminum Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior; use aluminum or galvanized-steel fasteners for surfaces exposed to the interior.

C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.

D. Lap-Seam Metal Panels: Fasten metal panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.

1. Apply panels and associated items true to line for neat and weathertight enclosure.
2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal panels.
3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.

E. Watertight Installation:

1. Apply a continuous ribbon of sealant or tape to seal lapped joints of metal panels, using sealant or tape as recommend by manufacturer on side laps of nesting-type panels and elsewhere as needed to make panels watertight.
2. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
3. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.

F. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal panel system including trim, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal panel manufacturer; or, if not indicated, provide types recommended by metal panel manufacturer.
- G. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that are permanently watertight.
1. Install exposed flashing and trim that is without buckling, and tool marks, and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to achieve waterproof performance.
 2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches (610 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).

3.4 CLEANING AND PROTECTION

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.
- B. After metal panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.
- C. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 074293

SECTION 07 54 19 - POLYVINYL-CHLORIDE (PVC) ROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Adhered polyvinyl chloride (PVC) roofing system.
2. Roof insulation.
3. Cover board.
4. Expansion Joint supports.

B. Related Requirements:

1. Section 061053 "Miscellaneous Rough Carpentry" for wood nailers, curbs, and blocking; and for wood-based, structural-use roof deck panels.
2. Section 076200 "Sheet Metal Flashing and Trim" for metal roof flashings, counterflashings, premanufactured copings and scuppers.
3. Section 077200 "Roof Accessories" for roof hatches.
4. Section 079200 "Joint Sealants" for joint sealants, joint fillers, and joint preparation.
5. Section 221423 "Storm Drainage and Roof Drains" for roof drains.

1.3 DEFINITIONS

- A. Roofing Terminology: Definitions in ASTM D1079 and glossary in NRCA's "The NRCA Roofing Manual: Membrane Roof Systems" apply to work of this Section.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Roofing Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Construction Manager, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include roof plans, sections, details, and attachments to other work, including the following:
 1. Layout and thickness of insulation.
 2. Base flashings and membrane terminations.
 3. Flashing details at penetrations.
 4. Tapered insulation thickness and slopes.
 5. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
- C. Samples for Verification: For the following products:
 1. Roof membrane and flashing, of color required.
- D. Wind Uplift Resistance Submittal: For roofing system, indicating compliance with wind uplift performance requirements.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and manufacturer.
- B. Manufacturer Certificates:
 1. Performance Requirement Certificate: Signed by roof membrane manufacturer, certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
 - a. Submit evidence of compliance with performance requirements.
 2. Special Warranty Certificate: Signed by roof membrane manufacturer, certifying that all materials supplied under this Section are acceptable for special warranty.
- C. Product Test Reports: For roof membrane and insulation, tests performed by independent qualified testing agency indicating compliance with specified requirements.
- D. Field quality-control reports.

- E. Sample Warranties: For manufacturer's special warranties.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For roofing system to include in maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer that is UL listed, listed in FM Approvals' RoofNav for roofing system identical to that used for this Project.
- B. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.
- B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
 - 1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.
- C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.
- D. Handle and store roofing materials, and place equipment in a manner to avoid permanent deflection of deck.

1.10 FIELD CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

1.11 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Special warranty includes roof membrane, base flashings, roof insulation, fasteners, cover boards, and other components of roofing system.
 2. Warranty Period: 30 years from date of Substantial Completion.
 3. Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by:
 - a. peak gust wind speed exceeding 90 mph;
 - b. lightning;
 - c. fire;
 - d. insect infestations;
 - e. earthquake;
 - f. tornado;
 - g. hail;
 - h. hurricane;
 - i. failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;
 - j. faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;
 - k. vapor condensation on bottom of roofing; and
 - l. activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner
- B. Special Project Warranty: Submit roofing Installer's warranty, on warranty form at end of this Section, signed by Installer, covering the Work of this Section, including all components of roofing system such as roof membrane, base flashing, roof insulation, fasteners, cover boards, and walkway products, for the following warranty period:
1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Installed roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roof system and flashings shall remain watertight.
1. Accelerated Weathering: Roof membrane shall withstand 2000 hours of exposure when tested according to ASTM G152, ASTM G154, or ASTM G155.
 2. Impact Resistance: Roof membrane shall resist impact damage when tested according to ASTM D3746, ASTM D4272/D4272M, or the "Resistance to Foot Traffic Test" in FM Approvals 4470.
- B. Material Compatibility: Roofing materials shall be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roof membrane manufacturer based on testing and field experience.

- C. Wind Uplift Resistance: Design roofing system to resist design wind uplift pressures when tested according to FM Approvals 4474, UL 580, or UL 1897.
 - 1. Wind Exposure: D.
 - 2. Wind Speed: 115 mph.
 - 3. Risk Category: II.
- D. SPRI's Directory of Roof Assemblies Listing: Roof membrane, base flashings, and component materials shall comply with requirements in FM Approvals 4450 or FM Approvals 4470 as part of a roofing system, and shall be listed in SPRI's Directory of Roof Assemblies for roof assembly identical for that specified for this Project.
 - 1. Wind Uplift Load Capacity: 90 psf.
- E. Exterior Fire-Test Exposure: ASTM E108 or UL 790, Class A; for application and roof slopes indicated; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

2.2 POLYVINYL CHLORIDE (PVC) ROOFING

- A. PVC Keytone Ethylene Ester (KEE) Alloy Sheet: ASTM D4434/D4434M, Type III.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Carlisle SynTec Incorporated.
 - b. GAF.
 - c. Johns Manville; a Berkshire Hathaway company.
 - 2. Membrane Thickness: 80 mils.
 - 3. Exposed Face Color: White.
- B. Source Limitations: Obtain components for roofing system from roof membrane manufacturer or manufacturers approved by roof membrane manufacturer.

2.3 AUXILIARY ROOFING MATERIALS

- A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with other roofing components.
 - 1. Adhesives and Sealants: Comply with VOC limits of authorities having jurisdiction.
- B. Expansion Joint Supports: Extruded EPDM expansion joint supports capable of supporting PVC roofing membrane above and acceptable to PVC roofing manufacturer.
 - 1. Width of Expansion Joint Capability: 3/4 inch minimum to 3 inch maximum.
- C. Sheet Flashing: Manufacturer's standard sheet flashing of same material, type, reinforcement, thickness, and color as PVC sheet.

- D. Prefabricated Pipe Flashings: As recommended by roof membrane manufacturer.
- E. Roof Vents: As recommended by roof membrane manufacturer.
 - 1. Size: Not less than 4-inch diameter.
- F. Bonding Adhesive: Manufacturer's standard.
- G. Slip Sheet: Manufacturer's standard, of thickness required for application.
- H. Metal Termination Bars: Manufacturer's standard, predrilled stainless steel or aluminum bars, approximately 1 by 1/8 inch thick; with anchors.
- I. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch thick, prepunched.
- J. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roofing components to substrate, and acceptable to roofing system manufacturer.
- K. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.

2.4 ROOF INSULATION

- A. General: Preformed roof insulation boards manufactured or approved by PVC roof membrane manufacturer, approved for use in SPRI's Directory of Roof Assemblies listed roof assemblies.
- B. Polyisocyanurate Board Insulation: ASTM C1289, Type II, Class 1, Grade 3, felt or glass-fiber mat facer on both major surfaces.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Carlisle SynTec Incorporated.
 - b. GAF.
 - c. Johns Manville; a Berkshire Hathaway company.
 - 2. Compressive Strength: 25 psi.
 - 3. Size: 48 by 96 inches.
- C. Tapered Insulation: Provide factory-tapered insulation boards.
 - 1. Material: Match roof insulation.
 - 2. Minimum Thickness: 1/4 inch.
 - 3. Slope:
 - a. Roof Field: 1/4 inch per foot unless otherwise indicated on Drawings.
 - b. Saddles and Crickets: 1/2 inch per foot unless otherwise indicated on Drawings.

2.5 INSULATION ACCESSORIES

- A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with other roofing system components.
- B. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards to substrate, and acceptable to roofing system manufacturer.
- C. Insulation Adhesive: Insulation manufacturer's recommended adhesive formulated to attach roof insulation to substrate or to another insulation layer.
- D. Cover Board: ASTM C1177/C1177M, glass-mat, water-resistant gypsum board or ASTM C1278/C1278M fiber-reinforced gypsum board.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Georgia-Pacific Gypsum LLC.
 - b. National Gypsum Company.
 - c. USG Corporation.
 - 2. Thickness: 5/8 inch.
 - 3. Surface Finish: Factory primed or unprimed as required by PVC roofing manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
 - 1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
 - 2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
 - 3. Verify that surface plane flatness and fastening of steel roof deck complies with requirements in Section 053100 "Steel Decking."
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing system installation according to roofing system manufacturer's written instructions. Remove sharp projections.

- B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.

3.3 INSTALLATION OF ROOFING, GENERAL

- A. Install roofing system according to roofing system manufacturer's written instructions, SPRI's Directory of Roof Assemblies listed roof assembly requirements, and FM Global Property Loss Prevention Data Sheet 1-29.
- B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at end of workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing..
- C. Coordinate installation and transition of roofing system component serving as an air barrier with air barrier specified under Section 072726 "Fluid-Applied Membrane Air Barriers."

3.4 INSTALLATION OF INSULATION

- A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at end of workday.
- B. Comply with roofing system and insulation manufacturer's written instructions for installing roof insulation.
- C. Installation Over Metal Decking:
 - 1. Install base layer of insulation with end joints staggered not less than 12 inches in adjacent rows and with long joints continuous at right angle to flutes of decking.
 - a. Locate end joints over crests of decking.
 - b. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 - c. Make joints between adjacent insulation boards not more than 1/4 inch in width.
 - d. At internal roof drains, slope insulation to create a square drain sump with each side equal to the diameter of the drain bowl plus 24 inches.
 - 1) Trim insulation so that water flow is unrestricted.
 - e. Fill gaps exceeding 1/4 inch with insulation.
 - f. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.
 - g. Mechanically attach base layer of insulation using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to metal decks.
 - 1) Fasten insulation according to requirements in SPRI's Directory of Roof Assemblies for specified Wind Uplift Load Capacity.
 - 2) Fasten insulation to resist specified uplift pressure at corners, perimeter, and field of roof.

2. Install upper layers of insulation and tapered insulation with joints of each layer offset not less than 12 inches from previous layer of insulation.
 - a. Install with long joints continuous and with end joints staggered not less than 12 inches in adjacent rows.
 - b. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 - c. Make joints between adjacent insulation boards not more than 1/4 inch in width.
 - d. At internal roof drains, slope insulation to create a square drain sump with each side equal to the diameter of the drain bowl plus 24 inches.
 - e. Trim insulation so that water flow is unrestricted.
 - f. Fill gaps exceeding 1/4 inch with insulation.
 - g. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.
 - h. Adhere each layer of insulation to substrate using adhesive according to SPRI's Directory of Roof Assemblies listed roof assembly requirements for specified Wind Uplift Load Capacity and FM Global Property Loss Prevention Data Sheet 1-29, as follows:

3.5 INSTALLATION OF COVER BOARDS

- A. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches in each direction.
 1. Trim cover board neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
 2. At internal roof drains, conform to slope of drain sump.
 - a. Trim cover board so that water flow is unrestricted.
 3. Cut and fit cover board tight to nailers, projections, and penetrations.
 4. Adhere cover board to substrate using adhesive according to SPRI's Directory of Roof Assemblies listed roof assembly requirements for specified Wind Uplift Load Capacity and FM Global Property Loss Prevention Data Sheet 1-29, as follows:
 - a. Set cover board in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.
- B. Install slip sheet over cover board and immediately beneath roof membrane if required.

3.6 INSTALLATION OF ADHERED ROOF MEMBRANE

- A. Adhere roof membrane over area to receive roofing according to roofing system manufacturer's written instructions.
- B. Unroll roof membrane and allow to relax before installing.
- C. Accurately align roof membrane, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

- D. Bonding Adhesive: Apply to substrate and underside of roof membrane at rate required by manufacturer, and allow to partially dry before installing roof membrane. Do not apply to splice area of roof membrane.
- E. In addition to adhering, mechanically fasten roof membrane securely at terminations, penetrations, and perimeter of roofing.
- F. Apply roof membrane with side laps shingled with slope of roof deck where possible.
- G. Seams: Clean seam areas, overlap roofing, and hot-air weld side and end laps of roof membrane and sheet flashings to ensure a watertight seam installation.
 - 1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of roof membrane and sheet flashings.
 - 2. Verify field strength of seams a minimum of twice daily, and repair seam sample areas.
 - 3. Repair tears, voids, and lapped seams in roof membrane that do not comply with requirements.
- H. Spread sealant bed over deck-drain flange at roof drains, and securely seal roof membrane in place with clamping ring.

3.7 INSTALLATION OF BASE FLASHING

- A. Install sheet flashings and preformed flashing accessories, and adhere to substrates according to roofing system manufacturer's written instructions.
- B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate, and allow to partially dry. Do not apply to seam area of flashing.
- C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
- D. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Hot-air weld side and end laps to ensure a watertight seam installation.
- E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.8 INSTALLATION OF WALKWAYS

- A. Flexible Walkways: Install walkway products according to manufacturer's written instructions.
 - 1. Install flexible walkways at the following locations:
 - a. At each access to roof hatch and/or top of each roof access ladder.
 - b. On portions low roofs where higher roofs above drain onto low roofs, including where standing-seam metal roofing drains onto PVC roofing.
 - c. As required by roof membrane manufacturer's warranty requirements.

2. Heat weld to substrate or adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to inspect substrate conditions, surface preparation, roof membrane application, sheet flashings, protection, and drainage components, and to furnish reports to Architect.
 1. Testing agency shall prepare survey report indicating locations of initial discontinuities, if any.
- B. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion, in presence of Architect, and to prepare inspection report.
- C. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.
- D. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

3.10 PROTECTING AND CLEANING

- A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing system for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.
- B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.
- C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

3.11 ROOFING INSTALLER'S WARRANTY

- A. WHEREAS _____ of _____, herein called the "Roofing Installer," has performed roofing and associated work ("work") on the following project:

1. Owner: _____.
2. Address: _____.
3. Building Name/Type: _____.
4. Address: _____.
5. Area of Work: _____.
6. Acceptance Date: _____.
7. Warranty Period: _____.
8. Expiration Date: _____.

- B. AND WHEREAS Roofing Installer has contracted (either directly with Owner or indirectly as a subcontractor) to warrant said work against leaks and faulty or defective materials and workmanship for designated Warranty Period,
- C. NOW THEREFORE Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period Roofing Installer will, at Roofing Installer's own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.
- D. This Warranty is made subject to the following terms and conditions:
1. Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by:
 - a. lightning;
 - b. peak gust wind speed exceeding 90 mph.
 - c. fire;
 - d. failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;
 - e. faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;
 - f. vapor condensation on bottom of roofing; and
 - g. activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.
 2. When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.
 3. Roofing Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.
 4. During Warranty Period, if Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless Roofing Installer, before starting said work, shall have notified Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.
 5. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.
 6. Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

7. This Warranty is recognized to be the only warranty of Roofing Installer on said work and shall not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

E. IN WITNESS THEREOF, this instrument has been duly executed this _____ day of _____, _____.

1. Authorized Signature: _____.
2. Name: _____.
3. Title: _____.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 07 54 19

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SECTION 07 60 00 – SHEET METAL GUTTERS AND DOWNSPOUTS

PART 1 – GENERAL

1.1 DESCRIPTION

- A. This Section includes specifications for manufacturing and installation of the gutters and downspouts as indicated on the contract documents.
- B. Related Work Specified Elsewhere:
 - 1. Section 05 31 00 – Steel Decking
 - 2. Section 05 50 00 – Metal Fabrications
 - 3. Section 07 41 13.16 – Standing-Seam Metal Roof Panels
 - 4. Section 075419 – Polyvinyl-Chloride (PVC) Roofing
 - 5. Section 09 91 00 – Painting

1.2 QUALITY CONTROL

- A. Installer Qualifications: Engage an experience Installer who has completed sheet metal work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- B. General: Install sheet metal to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing.
- C. Comply with applicable provisions of the following specifications and documents:
 - 1. Architectural Sheet Metal Manual by SMACNA requirements
 - 2. ASTM Specifications.

1.3 SUBMITTALS

- A. In accordance with Division 1, submit the following:
 - 1. Product Data: Product Data including manufacturer's material and finish data, installation instructions.
 - 2. Shop Drawings: Show layout and types of gutters and downspouts, anchorage details, methods of jointing, accessories, and attachments to other construction.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Hanging Gutters:
 - 1. Fabricate to size and profile indicated, complete with end pieces, outlet tubes, and other accessories as required.
 - 2. Gutters shall be complete with mitered corners, end caps, and outlets sized to fit downspouts.
 - 3. Gutter Material: Coil-Coated Galvanized Steel Sheet: Zinc-coated, commercial-quality steel sheet conforming to ASTM A 755, G 90 (ASTM A 755M, Z 275) coating designation, oil coated with high-performance fluoropolymer coating as specified, not

- less than 0.0276 inch thick.
- 4. Fabricate sections in maximum lengths practical; not less than 96 IN long.
- 5. Furnish flat-stock gutter spacers and gutter brackets fabricated from same metal as gutters, of size recommended by SMACNA but not less than twice gutter thickness.
- 6. Fabricate expansion joints, expansion-joint covers, gutter bead reinforcing bars, and gutter accessories from same metal as gutters.
- 7. Gutter supports shall be adjustable minimum 1 IN wide by minimum .080 IN thick hanger, provided in sufficient number to be located at maximum 30 IN on center, or minimum 0.032 IN thick continuous cleats.

B. Downspouts:

- 1. Fabricate downspouts to size and profile indicated complete with formed or mitered elbows.
- 2. Downspout Material: Coil-Coated Galvanized Steel Sheet: Zinc-coated, commercial-quality steel sheet conforming to ASTM A 755, G 90 (ASTM A 755M, Z 275) coating designation, oil coated with high-performance fluoropolymer coating as specified, not less than 0.0276 inch thick.
- 3. Shape: Rectangular.
- 4. Furnish with metal hangers, from same material as downspouts, and anchors.
- 5. Downspouts shall be fabricated in minimum 10 FT lengths with section ends formed for minimum 1/2 IN telescoped and locked joints.
- 6. Downspouts shall be complete with indicated elbows and offsets.

2.2 COIL-COATED GALVANIZED STEEL SHEET FINISH

A. High-Performance Organic Coating Finish: Apply the following system by coil-coating process on galvanized steel sheet as recommended by coating manufacturers and applicator.

- 1. Fluoropolymer 2-Coat Coating System: Manufacturer's standard 2-coat, thermocured system composed of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.
 - a. Color and Gloss: As indicated by manufacturer's color and gloss designations.
 - b. Color and Gloss: As selected by Architect from manufacturer's full range of choices for color and gloss.
 - c. Resin Manufacturers: Subject to compliance with requirements, provide fluoropolymer coating systems containing resins produced by one of the following manufacturers:
 - i. Ausimont USA, Inc. (Hylar 5000)
 - ii. Elf Atochem North America, Inc. (Kynar 500)
- 2. Coil-Coated Steel Sheet Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Atas Aluminum Corporation.
 - b. Copper Sales, Inc.
 - c. MM Systems Corporation.
 - d. Petersen Aluminum Corporation.
 - e. Vincent Metals.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Shop assemble work in largest practical sections; minimize field connections. Grind smooth parts exposed to view; remove weld marks and leave free of fabrication marks. Miter corners and edges unless otherwise shown. Make members true to length so assembling may be done without fillers. Bends, twists, open joints in finished members, or projecting edges or corners at connections will not be permitted. Miter, cope, and block carefully to produce tight joints. Provide lugs, clips, connections, bolts, and fastenings necessary to complete fabrication.
- B. General: Fabricate items in thickness or weight needed to comply with performance requirements but not less than that listed for each application and metal.
- C. Provide dissimilar metals and materials protection where dissimilar metals come in contact or where sheet metal contacts mortar, concrete masonry or concrete.
- D. Install products in accordance with manufacturer's instructions, SMACNA, and as indicated on Drawings.
- E. Installation – gutters and downspouts
 1. Install gutters below slope line of roof, supported on adjustable hangers spaced maximum 30 inches on center or by continuous cleats.
 2. Join gutter sections with flat locked, riveted and sealed joints with hard setting sealant fill to provide completely water tight system.
 3. Adjust gutters to slope uniformly to downspout outlets, with high point midway between outlets.
 4. Install downspouts in locations shown on the Drawings.
 5. Install downspouts supported by leader straps or concealed rack and pin type fasteners at top, bottom and intermediate points not exceeding 5 FT on center.
 6. Provide downspout anchor straps per SMACNA as appropriate for downspout style.
 7. Provide gutter to downspout connection per SMACNA Figure 1-33B, Detail 1.
 8. Seal all joints in downspout for a complete watertight system.
 9. Paint downspouts to match the canopy/roof.
 10. Provide all miscellaneous sheet metal items not specifically covered elsewhere, as indicated or required to provide a weather tight installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 07 60 00

SECTION 076200 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manufactured reglets with counterflashing.
2. Formed roof-drainage sheet metal fabrications.
3. Formed low-slope roof sheet metal fabrications.
4. Formed steep-slope roof sheet metal fabrications.
5. Formed wall sheet metal fabrications.
6. Formed equipment support flashing.
7. Formed overhead-piping safety pans.

B. Related Requirements:

1. Section 061053 "Miscellaneous Rough Carpentry" for wood nailers, curbs, and blocking.
2. Section 042100 "Clay Unit Masonry" for materials and installation of manufactured sheet metal through-wall flashing and trim integral with masonry.
3. Section 074113.16 "Standing Seam Metal Roof Panels" and 075423 "Thermoplastic-Polyolefin (TPO) Roofing" for materials and installation of sheet metal flashing and trim integral with roofing.
4. Section 074213.13 "Formed Metal Wall Panels" for sheet metal flashing and trim integral with metal wall panels.
5. Section 077129 "Manufactured Roof Expansion Joints" for materials and installation for sheet metal flashing integral with expansion joints.
6. Section 077200 "Roof Accessories" for set-on-type curbs, equipment supports, roof hatches, vents, and other manufactured roof accessory units.
7. Section 079513.16 "Exterior Expansion Joint Cover Assemblies" for manufactured expansion-joint cover assemblies for exterior building walls, soffits, and parapets.

1.3 COORDINATION

- A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.
- B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 2. Review special roof details, roof drainage, roof-penetration flashing, equipment curbs, and condition of other construction that affect sheet metal flashing and trim.
 - 3. Review requirements for insurance and certificates if applicable.
 - 4. Review sheet metal flashing observation and repair procedures after flashing installation.

1.5 ACTION SUBMITTALS

- A. Product Data: For each of the following
 - 1. Underlayment materials.
 - 2. Elastomeric sealant.
 - 3. Butyl sealant.
 - 4. Epoxy seam sealer.
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- C. Shop Drawings: For sheet metal flashing and trim.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Detail fabrication and installation layouts, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled Work.
 - 3. Include identification of material, thickness, weight, and finish for each item and location in Project.
 - 4. Include details for forming, including profiles, shapes, seams, and dimensions.
 - 5. Include details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
 - 6. Include details of termination points and assemblies.
 - 7. Include details of expansion joints and expansion-joint covers, including showing direction of expansion and contraction from fixed points.
 - 8. Include details of roof-penetration flashing.
 - 9. Include details of edge conditions, including eaves, ridges, valleys, rakes, crickets, flashings, and counterflashings.
 - 10. Include details of special conditions.
 - 11. Include details of connections to adjoining work.
 - 12. Detail formed flashing and trim at scale of not less than 1-1/2 inches per 12 inches (1:10).
- D. Samples: For each exposed product and for each color and texture specified, 12 inches (300 mm) long by actual width.
- E. Samples for Initial Selection: For each type of sheet metal and accessory indicated with factory-applied finishes.

F. Samples for Verification: For each type of exposed finish.

1. Sheet Metal Flashing: 12 inches (300 mm) long by actual width of unit, including finished seam and in required profile. Include fasteners, cleats, clips, closures, and other attachments.
2. Trim, Metal Closures, Expansion Joints, Joint Intersections, and Miscellaneous Fabrications: 12 inches (300 mm) long and in required profile. Include fasteners and other exposed accessories.
3. Unit-Type Accessories and Miscellaneous Materials: Full-size Sample.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For fabricator.
- B. Product Certificates: For each type of coping and roof edge flashing that is ANSI/SPRI/FM 4435/ES-1 tested.
- C. Product Test Reports: For each product, for tests performed by a qualified testing agency.
- D. Evaluation Reports: For copings and roof edge flashing, from an agency acceptable to authority having jurisdiction showing compliance with ANSI/SPRI/FM 4435/ES-1.
- E. Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sheet metal flashing and trim, and its accessories, to include in maintenance manuals.
- B. Special warranty.

1.8 QUALITY ASSURANCE

- A. Fabricator Qualifications: Employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.
 1. For copings and roof edge flashings that are ANSI/SPRI/FM 4435/ES-1 tested, shop shall be listed as able to fabricate required details as tested and approved.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
 1. Build mockup of typical roof edge, including fascia, approximately 10 feet long, including supporting construction cleats, seams, attachments, underlayment, and accessories.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage.
 1. Store sheet metal flashing and trim materials away from uncured concrete and masonry.
 2. Protect stored sheet metal flashing and trim from contact with water.
- B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to extent necessary for period of sheet metal flashing and trim installation.

1.10 WARRANTY

- A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.
 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sheet metal flashing and trim assemblies, including cleats, anchors, and fasteners, shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.
- B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA's "The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing"

SMACNA's "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.

- C. Sheet Metal Standard for Copper: Comply with CDA's "Copper in Architecture Handbook." Conform to dimensions and profiles shown unless more stringent requirements are indicated.
- D. SPRI Wind Design Standard: Manufacture and install copings and roof edge flashings tested in accordance with ANSI/SPRI/FM 4435/ES-1 and capable of resisting the following design pressure:
 - 1. Design Pressure: As indicated on Drawings.
- E. FM Approvals Listing: Manufacture and install copings and roof edge flashings that are listed in FM Approvals' "RoofNav" and approved for windstorm classification, Class 1-120. Identify materials with name of fabricator and design approved by FM Approvals.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 SHEET METALS

- A. Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.
- B. Stainless Steel Sheet: ASTM A240/A240M, Type 316, dead soft, fully annealed; with smooth, flat surface.
 - 1. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 20 percent.
 - 2. Finish: ASTM A480/A480M, No. 2D (dull, cold rolled).
 - a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1) Run grain of directional finishes with long dimension of each piece.
 - 2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.3 UNDERLAYMENT MATERIALS

- A. Self-Adhering, High-Temperature Sheet Underlayment: Minimum 30 mils (0.76 mm) thick, consisting of a slip-resistant polyethylene- or polypropylene-film top surface laminated to a

layer of butyl- or SBS-modified asphalt adhesive, with release-paper backing; specifically designed to withstand high metal temperatures beneath metal roofing. Provide primer in accordance with underlayment manufacturer's written instructions.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Carlisle WIP Products; a brand of Carlisle Construction Materials.
 - b. Henry Company.
 - c. Owens Corning.
2. Source Limitations: Obtain underlayment from single source from single manufacturer.
3. Low-Temperature Flexibility: ASTM D1970/D1970M; passes after testing at minus 20 deg F (29 deg C) or lower.

- B. Slip Sheet: Rosin-sized building paper, 3 lb/100 sq. ft. (0.16 kg/sq. m) minimum.

2.4 MISCELLANEOUS MATERIALS

- A. Provide materials and types of fasteners, solder, protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.
- B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.
1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
 - a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.
 - b. Blind Fasteners: High-strength aluminum or stainless steel rivets suitable for metal being fastened.
 2. Fasteners for Stainless Steel Sheet: Series 300 stainless steel.
 3. Fasteners for Aluminum-Zinc Alloy-Coated Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel in accordance with ASTM A153/A153M or ASTM F2329.
- C. Solder:
1. For Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless steel sheet manufacturer.
 2. For Zinc-Coated (Galvanized) Steel: ASTM B32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead with maximum lead content of 0.2 percent.
- D. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.

- E. Elastomeric Sealant: ASTM C920, elastomeric polysulfide polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
- F. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.
- G. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.
- H. Bituminous Coating: Cold-applied asphalt emulsion in accordance with ASTM D1187/D1187M.
- I. Asphalt Roofing Cement: ASTM D4586, asbestos free, of consistency required for application.
- J. Reglets: Units of type, material, and profile required, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions and with interlocking counterflashing on exterior face, of same metal as reglet.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fry Reglet Corporation.
 - b. Heckmann Building Products, Inc.
 - c. Keystone Flashing Company, Inc.
 - 2. Source Limitations: Obtain reglets from single source from single manufacturer.
 - 3. Material: Stainless steel, 0.0188 inch (0.477 mm) thick.
 - 4. Surface-Mounted Type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.
 - 5. Masonry Type: Provide with offset top flange for embedment in masonry mortar joint.
 - 6. Accessories:
 - a. Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where Drawings show reglet without metal counterflashing.
 - b. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing's lower edge.
 - 7. Finish: Mill.

2.5 FABRICATION, GENERAL

- A. Custom fabricate sheet metal flashing and trim to comply with details indicated and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required.
 - 1. Fabricate sheet metal flashing and trim in shop to greatest extent possible.
 - 2. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
 - 3. Verify shapes and dimensions of surfaces to be covered and obtain field measurements for accurate fit before shop fabrication.
 - 4. Form sheet metal flashing and trim to fit substrates without excessive oil-canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
 - 5. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.
- B. Fabrication Tolerances:
 - 1. Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.
 - 2. Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified.
- C. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.
 - 1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with butyl sealant concealed within joints.
 - 2. Use lapped expansion joints only where indicated on Drawings.
- D. Sealant Joints: Where movable, nonexpansion-type joints are required, form metal in accordance with cited sheet metal standard to provide for proper installation of elastomeric sealant.
- E. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.
- F. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard and by FM Global Property Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.
- G. Seams:
 - 1. Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 - 2. Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.
- H. Do not use graphite pencils to mark metal surfaces.

2.6 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

- A. Copings: Fabricate in minimum 96-inch- (2400-mm-) long, but not exceeding 12-foot- (3.6-m-) long, sections. Fabricate joint plates of same thickness as copings. Furnish with continuous cleats to support edge of external leg and interior leg. Miter corners, solder or weld watertight. Shop fabricate interior and exterior corners.
 - 1. Coping Profile: Fig. 3-4B in accordance with SMACNA's "Architectural Sheet Metal Manual."
 - 2. Joint Style: Butted with expansion space and 6-inch- (150-mm-) wide, exposed cover plate.
 - 3. Fabricate from the following materials:
 - a. Match metal form wall/soffit panels
- B. Roof and Roof-to-Wall Transition Expansion-Joint Cover: Shop fabricate interior and exterior corners. Fabricate from the following materials:
 - 1. Stainless Steel: 0.0250 inch (0.635 mm) thick.
- C. Base Flashing: Shop fabricate interior and exterior corners. Fabricate from the following materials:
 - 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.
- D. Counterflashing: Shop fabricate interior and exterior corners. Fabricate from the following materials:
 - 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.
- E. Flashing Receivers: Fabricate from the following materials:
 - 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.
- F. Roof-Penetration Flashing: Fabricate from the following materials:
 - 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.
- G. Roof-Drain Flashing: Fabricate from the following materials:
 - 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.

2.7 STEEP-SLOPE ROOF SHEET METAL FABRICATIONS

- A. Apron, Step, Cricket, and Backer Flashing: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
- B. Valley Flashing: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
- C. Drip Edges: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
- D. Eave, Rake, Ridge, and Hip Flashing: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.

- E. Counterflashing: Shop fabricate interior and exterior corners. Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
- F. Flashing Receivers: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch (0.56 mm) thick.
- G. Roof-Penetration Flashing: Fabricate from the following materials:
 - 1. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.

2.8 WALL SHEET METAL FABRICATIONS

- A. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch- (2400-mm-) long, but not exceeding 12-foot- (3.6-m-) long, sections, under copings, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches (150 mm) beyond each side of wall openings; and form with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:
 - 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.
- B. Opening Flashings in Frame Construction: Fabricate head, sill, jamb, and similar flashings to extend 4 inches (100 mm) beyond wall openings. Form head and sill flashing with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:
 - 1. Stainless Steel: 0.0156 inch (0.396 mm) thick.
- C. Wall Expansion-Joint Cover: Fabricate from the following materials:
 - 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.

2.9 MISCELLANEOUS SHEET METAL FABRICATIONS

- A. Equipment Support Flashing: Fabricate from the following materials:
 - 1. Stainless Steel: 0.0188 inch (0.477 mm) thick.
- B. Overhead-Piping Safety Pans: Fabricate from the following materials:
 - 1. Stainless Steel: 0.0250 inch (0.635 mm) thick.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances, substrate, and other conditions affecting performance of the Work.
 - 1. Verify compliance with requirements for installation tolerances of substrates.
 - 2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.

3. Verify that air- or water-resistant barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF UNDERLAYMENT

- A. Self-Adhering, High-Temperature Sheet Underlayment:

1. Install self-adhering, high-temperature sheet underlayment; wrinkle free.
2. Prime substrate if recommended by underlayment manufacturer.
3. Comply with temperature restrictions of underlayment manufacturer for installation; use primer for installing underlayment at low temperatures.
4. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses.
5. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps and edges with roller.
6. Roll laps and edges with roller.
7. Cover underlayment within 14 days.

- B. Install slip sheet, wrinkle free, over underlayment before installing sheet metal flashing and trim.

1. Install in shingle fashion to shed water.
2. Lapp joints not less than 4 inches (100 mm).

3.3 INSTALLATION, GENERAL

- A. Install sheet metal flashing and trim to comply with details indicated and recommendations of cited sheet metal standard that apply to installation characteristics required unless otherwise indicated on Drawings.

1. Install fasteners, solder, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
2. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder.
3. Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement.
4. Install sheet metal flashing and trim to fit substrates and to result in watertight performance.
5. Install continuous cleats with fasteners spaced not more than 12 inches (300 mm) o.c.
6. Space individual cleats not more than 12 inches (300 mm) apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
7. Install exposed sheet metal flashing and trim with limited oil-canning, and free of buckling and tool marks.
8. Do not field cut sheet metal flashing and trim by torch.
9. Do not use graphite pencils to mark metal surfaces.

- B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by

painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.

1. Coat concealed side of stainless steel sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
 2. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.
- C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim.
1. Space movement joints at maximum of 10 feet (3 m) with no joints within 24 inches (600 mm) of corner or intersection.
 2. Form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with sealant concealed within joints.
 3. Use lapped expansion joints only where indicated on Drawings.
- D. Fasteners: Use fastener sizes that penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.
- E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
- F. Seal joints as required for watertight construction.
1. Use sealant-filled joints unless otherwise indicated.
 - a. Embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant.
 - b. Form joints to completely conceal sealant.
 - c. When ambient temperature at time of installation is between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way.
 - d. Adjust setting proportionately for installation at higher ambient temperatures.
 - 1) Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).
 2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."
- G. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter.
1. Pretin edges of sheets with solder to width of 1-1/2 inches (38 mm); however, reduce pretinning where pretinned surface would show in completed Work.
 2. Do not solder metallic-coated steel and aluminum sheet.
 3. Do not pretin zinc-tin alloy-coated copper.
 4. Do not use torches for soldering.
 5. Heat surfaces to receive solder, and flow solder into joint.
 - a. Fill joint completely.
 - b. Completely remove flux and spatter from exposed surfaces.

6. Stainless Steel Soldering:

- a. Tin edges of uncoated sheets, using solder for stainless steel and acid flux.
- b. Promptly remove acid-flux residue from metal after tinning and soldering.
- c. Comply with solder manufacturer's recommended methods for cleaning and neutralization.

H. Rivets: Rivet joints in zinc where necessary for strength.

3.4 INSTALLATION OF ROOF FLASHINGS

A. Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and cited sheet metal standard.

1. Provide concealed fasteners where possible, and set units true to line, levels, and slopes.
2. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

B. Roof Edge Flashing:

1. Install roof edge flashings in accordance with ANSI/SPRI/FM 4435/ES-1.
2. Anchor to resist uplift and outward forces in accordance with recommendations in cited sheet metal standard unless otherwise indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at staggered 3-inch (75-mm) centers.
3. Anchor to resist uplift and outward forces in accordance with recommendations in FM Global Property Loss Prevention Data Sheet 1-49 for FM Approvals' listing for required windstorm classification.

C. Copings:

1. Install roof edge flashings in accordance with ANSI/SPRI/FM 4435/ES-1.
2. Anchor to resist uplift and outward forces in accordance with recommendations in FM Global Property Loss Prevention Data Sheet 1-49 for specified FM Approvals' listing for required windstorm classification.

D. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending minimum of 4 inches (100 mm) over base flashing. Install stainless steel draw band and tighten.

E. Counterflashing: Coordinate installation of counterflashing with installation of base flashing.

1. Insert counterflashing in reglets or receivers and fit tightly to base flashing.
2. Extend counterflashing 4 inches (100 mm) over base flashing.
3. Lap counterflashing joints minimum of 4 inches (100 mm).
4. Secure in waterproof manner by means of interlocking folded seam or blind rivets and sealant unless otherwise indicated.

- F. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.

3.5 INSTALLATION OF WALL FLASHINGS

- A. Install sheet metal wall flashing to intercept and exclude penetrating moisture in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.
- B. Opening Flashings in Frame Construction: Install continuous head, sill, jamb, and similar flashings to extend 4 inches (100 mm) beyond wall openings.
- C. Reglets: Installation of reglets is specified in Section 033000 "Cast-in-Place Concrete." Section 042000 "Unit Masonry." Section 042100 "Clay Unit Masonry – Thin Brick".

3.6 INSTALLATION OF MISCELLANEOUS FLASHING

- A. Equipment Support Flashing:
 - 1. Coordinate installation of equipment support flashing with installation of roofing and equipment.
 - 2. Weld or seal flashing with elastomeric sealant to equipment support member.
- B. Overhead-Piping Safety Pans:
 - 1. Suspend pans from structure above, independent of other overhead items such as equipment, piping, and conduit, unless otherwise indicated on Drawings.
 - 2. Pipe and install drain line to plumbing waste or drainage system.

3.7 INSTALLATION TOLERANCES

- A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

3.8 CLEANING

- A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
- B. Clean and neutralize flux materials. Clean off excess solder.
- C. Clean off excess sealants.

3.9 PROTECTION

- A. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions.
- B. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended in writing by sheet metal flashing and trim manufacturer.
- C. Maintain sheet metal flashing and trim in clean condition during construction.
- D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures, as determined by Architect.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 076200

SECTION 07 71 29 - MANUFACTURED ROOF EXPANSION JOINTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Flanged bellows-type roof expansion joints.
 - 2. Aluminum roof expansion joints.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For roof expansion joints.
- C. Samples: For each exposed product and for each color specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification data.
- B. Product test reports.
- C. Sample warranty.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Installer of roofing membrane.

1.6 WARRANTY

- A. Special Warranty: Manufacturer and Installer agree to repair or replace roof expansion joints and components that leak, deteriorate beyond normal weathering, or otherwise fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 NOT USED****2.2 FLANGED BELLOWS-TYPE ROOF EXPANSION JOINTS**

- A. Flanged Bellows-Type Roof Expansion Joint: Factory-fabricated, continuous, waterproof joint cover consisting of exposed membrane bellows laminated to flexible, closed-cell support foam, and secured along each edge to 3- to 4-inch- wide metal flange.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Balco, Inc.
 - b. BASF Corp. - Watson Bowman Acme Corp.
 - c. InPro Corporation (IPC).
 - d. Johns Manville; a Berkshire Hathaway company.
2. Source Limitations: Obtain flanged bellows-type roof expansion joints approved by roofing manufacturer and that are part of roofing membrane warranty.
3. Bellows: EPDM flexible membrane, nominal 60 mils thick.
4. Flanges: Aluminum, 0.032 inch thick.
5. Corner, Intersection, and Transition Units: Provide factory-fabricated units for corner and joint intersections and horizontal and vertical transitions including those to other building expansion joints.
6. Accessories: Provide splicing units, adhesives, and other components as recommended by roof-expansion-joint manufacturer for complete installation.
7. Secondary Seal: Continuous, waterproof membrane within joint and attached to substrate on sides of joint below the primary bellows assembly.

B. Materials:

1. Galvanized-Steel Sheet: ASTM A 653/A 653M, hot-dip zinc-coating designation G90.
2. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304.
3. Aluminum Sheet: ASTM B 209, mill finish, with temper to suit forming operations and performance required.
 - a. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious or preservative-treated wood materials.
4. EPDM Membrane: ASTM D 4637/D 4637M, type standard with manufacturer for application.

2.3 ALUMINUM ROOF EXPANSION JOINTS

- A. Aluminum Roof Expansion Joint: Factory-fabricated, continuous, waterproof joint cover; consisting of a formed or extruded metal cover secured to extruded aluminum frames, with

water-resistant gasketing between cover and frames, and with provision for securing assembly to substrate and sealing assembly to roofing membrane or flashing.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Balco, Inc.
 - b. BASF Corp. - Watson Bowman Acme Corp.
 - c. Construction Specialties.
 - d. InPro Corporation (IPC).
2. Frame Members: Extruded aluminum configured with integral aluminum curb as indicated; with exposed finish matching cover as selected by Architect from manufacturer's full range .
3. Cover: Formed or extruded aluminum; thickness as recommended by manufacturer .
4. Corner, Intersection, and Transition Units: Provide factory-fabricated units for corner and joint intersections and horizontal and vertical transitions including those to other building expansion joints.
5. Accessories: Provide splicing units, adhesives, and other components as recommended by roof-expansion-joint manufacturer for complete installation.
6. Secondary Seal: Continuous, waterproof membrane within joint and attached to substrate on sides of joint below the cover.

B. Materials:

1. Aluminum: ASTM B 209 for sheet and plate, ASTM B 221 for extrusions; alloy as standard with manufacturer for finish required, with temper to suit forming operations and performance required.
 - a. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious or preservative-treated wood materials.
 - b. Mill Finish: As manufactured.
2. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304; finish 2B.

2.4 MISCELLANEOUS MATERIALS

- A. Adhesives: As recommended by roof-expansion-joint manufacturer. Confirm compatibility with roofing manufacturer regarding contact with roofing membrane materials and assembly.
- B. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to withstand design loads.
 1. Exposed Fasteners: Gasketed. Use screws with hex washer heads matching color of material being fastened.
- C. Mineral-Fiber Blanket: ASTM C 665.
- D. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Comply with manufacturer's written instructions for handling and installing roof expansion joints.
 - 1. Anchor roof expansion joints securely in place, with provisions for required movement. Use fasteners, protective coatings, sealants, and miscellaneous items as required to complete roof expansion joints.
 - 2. Install roof expansion joints true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
 - 3. Provide for linear thermal expansion of roof expansion joint materials.
- B. Splices: Not permitted
- C. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 077129

SECTION 07 72 00 - ROOF ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Roof hatches.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of roof accessory.
- B. Shop Drawings: For roof accessories.
- C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

- A. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 WARRANTY

- A. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finishes or replace roof accessories that show evidence of deterioration of factory-applied finishes within 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ROOF HATCH

- A. Roof Hatches: Metal roof-hatch units with lids and insulated single -walled curbs, welded or mechanically fastened and sealed corner joints, continuous lid-to-curb counterflashing and weathertight perimeter gasketing stepped integral metal cant raised the thickness of roof insulation, and integrally formed deck-mounting flange at perimeter bottom.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Acudor Products, Inc.
 - b. AES Industries, Inc.
 - c. Babcock-Davis.
 - d. Bilco Company (The).
 - e. KCC International Inc.
 - f. Kingspan Light + Air, North America.
 - g. Milcor; Commercial Products Group of Hart & Cooley, Inc.
- B. Type and Size: Single-leaf lid, 36 by 36 inches.
- C. Loads: Minimum 40-lbf/sq. ft. external live load and 20-lbf/sq. ft. internal uplift load.
- D. Hatch Material: Stainless-steel sheet.
 1. Thickness: Manufacturer's standard thickness for hatch size indicated
 2. Finish: Manufacturer's standard.
- E. Construction:
 1. Nailer: Factory-installed wood nailer continuous around hatch perimeter.
 2. Hatch Lid: Opaque, insulated, and double walled, with manufacturer's standard metal liner of same material and finish as outer metal lid.
 3. Curb Liner: Manufacturer's standard, of same material and finish as metal curb.
 4. Fabricate curbs to minimum height of 12 inches above roofing surface unless otherwise indicated.
- F. Hardware: Spring operators, hold-open arm, stainless-steel spring latch with turn handles, stainless-steel butt- or pintle-type hinge system, and padlock hasps inside and outside.
- G. Safety Railing System: Roof-hatch manufacturer's standard system including rails, clamps, fasteners, safety barrier at railing opening, and accessories required for a complete installation; attached to roof hatch and complying with 29 CFR 1910.23 requirements and authorities having jurisdiction.
 1. Height: 42 inches above finished roof deck.
 2. Posts and Rails: Galvanized-steel pipe, 1-1/4 inches in diameter or galvanized-steel tube, 1-5/8 inches in diameter.
 3. Flat Bar: Galvanized steel, 2 inches high by 3/8 inch thick.
 4. Maximum Opening Size: System constructed to prevent passage of a sphere 21 inches in diameter.
 5. Chain Passway Barrier: Galvanized proof coil chain with quick link on fixed end.
 6. Self-Latching Gate: Fabricated of same materials and rail spacing as safety railing system. Provide manufacturer's standard hinges and self-latching mechanism.
 7. Post and Rail Tops and Ends: Weather resistant, closed or plugged with prefabricated end fittings.
 8. Provide weep holes or another means to drain entrapped water in hollow sections of handrail and railing members.

9. Fabricate joints exposed to weather to be watertight.
 10. Fasteners: Manufacturer's standard, finished to match railing system.
 11. Finish: Manufacturer's standard.
- H. Ladder-Assist Post: Roof-hatch manufacturer's standard device for attachment to roof-access ladder.
1. Operation: Post locks in place on full extension; release mechanism returns post to closed position.
 2. Height: 42 inches above finished roof deck.
 3. Material: Stainless steel
 4. Post: 1-5/8-inch diameter pipe.
 5. Finish: Manufacturer's standard.

2.2 METAL MATERIALS

- A. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 coating designation and mill phosphatized for field painting where indicated.
1. Mill-Phosphatized Finish: Manufacturer's standard for field painting.
 2. Factory Prime Coating: Where field painting is indicated, apply pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat, with a minimum dry film thickness of 0.2 mil.
 3. Exposed Coil-Coated Finish: Prepainted by the coil-coating process to comply with ASTM A 755/A 755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - a. Two-Coat Fluoropolymer Finish: AAMA 621. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.
- B. Aluminum Extrusions and Tubes: ASTM B 221, manufacturer's standard alloy and temper for type of use, finished to match assembly where used; otherwise mill finished.
- C. Stainless-Steel Sheet and Shapes: ASTM A 240/A 240M or ASTM A 666, Type 304.
- D. Steel Shapes: ASTM A 36/A 36M, hot-dip galvanized according to ASTM A 123/A 123M unless otherwise indicated.
- E. Galvanized-Steel Tube: ASTM A 500/A 500M, round tube, hot-dip galvanized according to ASTM A 123/A 123M.
- F. Steel Pipe: ASTM A 53/A 53M, galvanized.

2.3 MISCELLANEOUS MATERIALS

- A. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.

- B. Polyisocyanurate Board Insulation: ASTM C 1289, thickness and thermal resistivity as indicated.
- C. Wood Nailers: Softwood lumber, pressure treated with waterborne preservatives for aboveground use, acceptable to authorities having jurisdiction, containing no arsenic or chromium, and complying with AWPA C2; not less than 1-1/2 inches thick.
- D. Underlayment:
 - 1. Felt: ASTM D 226/D 226M, Type II (No. 30), asphalt-saturated organic felt, nonperforated.
 - 2. Polyethylene Sheet: 6-mil- thick polyethylene sheet complying with ASTM D 4397.
 - 3. Slip Sheet: Building paper, 3 lb/100 sq. ft. minimum, rosin sized.
 - 4. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
 - 5. Fasteners: Roof accessory manufacturer's recommended fasteners suitable for application and metals being fastened. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners. Furnish the following unless otherwise indicated:
- E. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, PVC, or silicone or a flat design of foam rubber, sponge neoprene, or cork.
- F. Elastomeric Sealant: ASTM C 920, elastomeric polymer sealant as recommended by roof accessory manufacturer for installation indicated; low modulus; of type, grade, class, and use classifications required to seal joints and remain watertight.
- G. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for expansion joints with limited movement.
- H. Asphalt Roofing Cement: ASTM D 4586/D 4586M, asbestos free, of consistency required for application.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Verify dimensions of roof openings for roof accessories. Install roof accessories according to manufacturer's written instructions.
 - 1. Install roof accessories level; plumb; true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
 - 2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
 - 3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
 - 4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.

- B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
 - 1. Coat concealed side of uncoated aluminum and stainless-steel roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
 - 2. Underlayment: Where installing roof accessories directly on cementitious or wood substrates, install a course of underlayment and cover with manufacturer's recommended slip sheet.
- C. Seal joints with elastomeric sealant as required by roof accessory manufacturer.

3.2 REPAIR AND CLEANING

- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A 780/A 780M.
- B. Touch up factory-primed surfaces with compatible primer ready for field painting according to Section 099113 "Exterior Painting."
- C. Clean exposed surfaces according to manufacturer's written instructions.
- D. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 077200

SECTION 07 92 00 - JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Silicone joint sealants.
2. Urethane joint sealants.
3. Latex joint sealants.

1.2 RELATED SECTIONS

- A. Section 04 20 00 "Unit Masonry"
- B. Section 04 21 00 "Unit Masonry - Thin Brick"
- C. Section 08 11 13 "Hollow Metal Doors and Frames"
- D. Section 08 31 13 "Access Doors and Frames".
- E. Section 09 29 00 "Gypsum Board"

1.3 REFERENCES

- A. See Section 01 42 00 REFERENCES AND DEFINITIONS for additional requirements.
- B. American Society of Testing and Materials (ASTM)
 1. ASTM C 834 - Standard Specification for Latex Sealants
 2. ASTM C 920 - Standard Specification for Elastomeric Joint Sealants
 3. ASTM C 1021 - Standard Practice for Laboratories Engaged in Testing of Building Sealants
 4. ASTM C 1193 - Standard Guide for Use of Joint Sealants
 5. ASTM C 1248 - Standard Test Method for Staining of Porous Substrate by Joint Sealants
 6. ASTM C 1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid Applied Sealants
 7. ASTM C 1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints
 8. ASTM E 90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
- C. Code of Federal Regulations (CFR)
 1. 40 CFR 59 - National Volatile Organic Compound Emission Standards for Consumer and Commercial Products

1.4 SUBMITTALS

- A. See Section 01 33 00 SUBMITTAL PROCEDURES for administrative and procedural requirements pertaining to Submittals.
- B. Product Data: For each joint-sealant product indicated.

- C. Samples: For each kind and color of joint sealant required.
- D. Joint-Sealant Schedule: Include the following information:
 - 1. Joint-sealant application, joint location, and designation.
 - 2. Joint-sealant manufacturer and product name.
 - 3. Joint-sealant formulation.
 - 4. Joint-sealant color.
- E. Informational Submittals
 - 1. Product test reports.
 - 2. Preconstruction compatibility and adhesion test reports.
 - 3. Preconstruction field-adhesion test reports.
 - 4. Field-adhesion test reports.
 - 5. Warranties.

1.5 QUALITY ASSURANCE

- A. See Section 01 43 00 QUALITY ASSURANCE for administrative and procedural requirements.
- B. Preinstallation Conference: Conduct conference at Project site in accordance with Section 01 31 00 PROJECT MANAGEMENT AND COORDINATION: Conduct conference at Project site.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
 - 1. Architectural Sealants: 250 g/L.
 - 2. Sealant Primers for Nonporous Substrates: 250 g/L.
 - 3. Sealant Primers for Porous Substrates: 775 g/L.
- B. Liquid-Applied Joint Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied joint sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
 - 1. Suitability for Immersion in Liquids. Where sealants are indicated for Use I for joints that will be continuously immersed in liquids, provide products that have undergone testing according to ASTM C 1247. Liquid used for testing sealants is deionized water, unless otherwise indicated.
- C. Stain-Test-Response Characteristics: Where sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.

D. Silicone Joint Sealant: ASTM C 920.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Corning Corporation.
 - b. Momentive/GE Advanced Materials - Silicones.
 - c. Tremco Incorporated.
 - d. Or approved equal
2. Type: Single component (S) or multicomponent (M).
3. Grade: nonsag (NS).
4. Class: 50.
5. Uses Related to Exposure: Nontraffic (NT).

E. Urethane Joint Sealant: ASTM C 920.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. BASF Building Systems.
 - b. Bostik, Inc.
 - c. Pacific Polymers International, Inc.
 - d. Pecora Corporation.
 - e. Sika Corporation; Construction Products Division.
 - f. Tremco Incorporated.
 - g. Or approved equal
2. Type: Single component (S) or multicomponent (M).
3. Grade: nonsag (NS).
4. Class: 25.
5. Uses Related to Exposure: Traffic (T) or Nontraffic (NT) to suit applications.

F. Latex Joint Sealant: Acrylic latex or siliconized acrylic latex, ASTM C 834, Type OP, Grade NF.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. BASF Building Systems.
 - b. Bostik, Inc.
 - c. Pecora Corporation.
 - d. Tremco Incorporated.
 - e. Or approved equal

G. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin) Type O (open-cell material) Type B (bicellular material with a surface skin) or any of the

preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

- H. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer.
- I. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- J. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials.
- K. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

2.2 INSPECTION AND TESTING

- A. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers eight samples of materials that will contact or affect joint sealants. Use ASTM C 1087 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
- B. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates. Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.

2.3 WARRANTY

- A. Special Manufacturer's Warranty: Manufacturer's standard form in which joint-sealant manufacturer agrees to furnish joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.
 - 1. Remove laitance and form-release agents from concrete.
 - 2. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.

- B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.2 INSTALLATION

- A. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- B. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.
 - 3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.
- C. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- D. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- E. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealant from surfaces adjacent to joints.
 - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 - 3. Provide concave joint profile per Figure 8A in ASTM C 1193, unless otherwise indicated.
- F. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.3 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:

1. Extent of Testing: Test completed, and cured sealant joints as follows:
 - a. Perform 1 test for the first 50 feet of joint length for each kind of sealant and joint substrate.
 - b. Perform 1 test for each 50 feet of joint length thereafter or 1 test per each floor per elevation.
2. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.

B. Evaluation of Field-Adhesion Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. No separate measurement will be made for the work of this section.

4.2 PAYMENT

- A Payment of the work of this section will be included in lump sum payment(s) for the applicable building or facility in accordance with the Schedule of Values

END OF SECTION 07 92 00

SECTION 07 95 13.16 - EXTERIOR EXPANSION JOINT COVER ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes exterior building expansion joint cover assemblies.
- B. Related Requirements:
 - 1. Section 077129 "Manufactured Roof Expansion Joints" for factory-fabricated roof expansion joint cover assemblies.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For each expansion joint cover assembly.
 - 1. Include plans, elevations, sections, details, splices, block-out requirement, attachments to other work, and line diagrams.
- C. Samples: For each exposed expansion joint cover assembly and for each color and texture specified.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Furnish units in longest practicable lengths to minimize field splicing.
- B. Include factory-fabricated closure materials and transition pieces, T-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous expansion joint cover assemblies.

2.2 PERFORMANCE REQUIREMENTS

- A. Expansion Joint Design Criteria
 - 1. Type of Movement: Thermal & wind sway.
 - a. Nominal Joint Width: As indicated on Drawings.
 - b. Minimum Joint Width: Nominal Joint width - $\frac{3}{4}$ ".
 - c. Maximum Joint Width: Nominal Joint width + $\frac{3}{4}$ ".

- d. If retaining "Type of Movement" Subparagraph below, indicate on Drawings horizontal, lateral, and vertical movement capability required for each expansion joint.

2.3 EXTERIOR EXPANSION JOINT COVERS

- A. Exterior Metal-Plate Joint Cover: Assembly consisting of sliding metal cover plate in continuous contact with gaskets mounted on metal frames fixed to sides of joint gap.
 1. Application:
 - a. Platform canopy to canopy
 - b. Bridge deck to bridge deck
 - c. Bridge Roof to bridge roof
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Corp. - Watson Bowman Acme Corp.
 - b. Construction Specialties, Inc.
 - c. Nystrom, Inc.
 3. Installation: Surface mounted.
 4. Exposed Metal:
 - a. Manufacturer's standard.
- B. Exterior Elastomeric-Seal Joint Cover: Assembly consisting of elastomeric seal anchored to surface-mounted frames fixed to sides of joint gap.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Corp. - Watson Bowman Acme Corp.
 - b. Construction Specialties, Inc.
 - c. Nystrom, Inc.
 2. Application:
 - a. Platform canopy to canopy
 - b. Bridge deck to bridge deck
 - c. Bridge Roof to bridge roof
 3. Installation: Surface-mounted.
 4. Exposed Metal:
 - a. Manufacturer's standard.
 5. Seal: Preformed elastomeric membrane or extrusion.
 - a. Color: Gray.

2.4 MATERIALS

- A. Aluminum: ASTM B 221, Alloy 6063-T5 for extrusions; ASTM B 209, Alloy 6061-T6 for sheet and plate.
- B. Elastomeric Seals: Manufacturer's standard preformed elastomeric membranes or extrusions to be installed in metal frames.
- C. Moisture Barrier: Manufacturer's standard, flexible elastomeric material.

2.5 ALUMINUM FINISHES

- A. Mill finish.
- B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

2.6 ACCESSORIES

- A. Manufacturer's standard attachment devices, as indicated or required for complete installations.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Prepare substrates according to expansion joint cover assembly manufacturer's written instructions.
- B. Coordinate and furnish anchorages, setting drawings, and instructions for installing expansion joint cover assemblies. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of expansion joint cover assemblies.
- C. Comply with manufacturer's written instructions for storing, handling, and installing expansion joint cover assemblies and materials unless more stringent requirements are indicated.
- D. Metal Frames: Perform cutting, drilling, and fitting required to install expansion joint cover assemblies.
 - 1. Install in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
 - 2. Adjust for differences between actual structural gap and nominal design gap due to ambient temperature at time of installation.
 - 3. Cut and fit ends to accommodate thermal expansion and contraction of metal without buckling of frames.
 - 4. Install frames in continuous contact with adjacent surfaces.
 - 5. Locate anchors at interval recommended by manufacturer, but not less than 3 inches from each end and not more than 24 inches o.c.

- E. Seals: Install elastomeric seals and membranes in frames to comply with manufacturer's written instructions. Install with minimum number of end joints.
 - 1. Provide in continuous lengths for straight sections.
 - 2. Seal transitions. Vulcanize or heat-weld field-spliced joints as recommended by manufacturer.
 - 3. Installation: Mechanically lock seals into frames or adhere to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
- F. Install with hairline mitered corners where expansion joint cover assemblies change direction or abut other materials.
- G. Terminate exposed ends of expansion joint cover assemblies with field- or factory-fabricated termination devices.
- H. Transition to Roof Expansion Joint Covers: Coordinate installation of exterior expansion joint covers with canopy roof system. Install factory-fabricated units at transition between exterior canopies.

3.2 PROTECTION

- A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.
- B. Protect the installation from damage by work of other Sections.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 07 95 13.16

SECTION 08 11 13 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes:
 - 1. Exterior standard steel doors and frames.
- B. Related Sections:
 - 1. Section 08 70 00 "Hardware"
 - 2. Section 09 91 13 "Exterior Painting".

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
- C. Shop Drawings: Include the following:
 - 1. Elevations of each door type.
 - 2. Details of doors, including vertical- and horizontal-edge details and metal thicknesses.
 - 3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
- D. Product Schedule: For hollow-metal doors and frames, prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final door hardware schedule.

1.4 INFORMATIONAL SUBMITTALS

- A. Product test reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Apex Industries, Inc.
2. Republic Doors and Frames.
3. Steelcraft; an Allegion brand.

2.2 EXTERIOR STANDARD STEEL DOORS AND FRAMES

- A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.
- B. Heavy-Duty Doors and Frames: SDI A250.8, Level 2; SDI A250.4, Level B. All Exterior Doors.
 1. Doors:
 - a. Type: As indicated in the Door and Frame Schedule.
 - b. Thickness: 1-3/4 inches.
 - c. Face: Metallic-coated steel sheet, minimum thickness of 0.042 inch, with minimum A40 coating.
 - d. Edge Construction: Model 2, Seamless.
 - e. Edge Bevel: Provide manufacturer's standard beveled or square edges.
 - f. Top Edge Closures: Close top edges of doors with flush closures of same material as face sheets. Seal joints against water penetration.
 - g. Bottom Edges: Close bottom edges of doors with end closures or channels of same material as face sheets. Provide weep-hole openings in bottoms of exterior doors to permit moisture to escape.
 - h. Core: Polyurethane.
 2. Frames:
 - a. Materials: Metallic-coated steel sheet, minimum thickness of 0.053 inch, with minimum A60 coating.
 - b. Construction: Full profile welded.

2.3 FRAME ANCHORS

- A. Jamb Anchors:
 1. Type: Anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.
 2. Quantity: Minimum of three anchors per jamb, with one additional anchor for frames with no floor anchor. Provide one additional anchor for each 24 inches of frame height above 7 feet.
- B. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor.

2.4 MATERIALS

- A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.
- B. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.
- C. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B.
- D. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.
- E. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.
- F. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.

2.5 FABRICATION

- A. Hollow-Metal Frames: Fabricate in one piece except where handling and shipping limitations require multiple sections. Where frames are fabricated in sections, provide alignment plates or angles at each joint, fabricated of metal of same or greater thickness as frames.
 - 1. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - 2. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.
 - a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
- B. Hardware Preparation: Factory prepare hollow-metal doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping according to SDI A250.6, the Door Hardware Schedule, and templates.
 - 1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
 - 2. Comply with BHMA A156.115 for preparing hollow-metal doors and frames for hardware.

2.6 STEEL FINISHES

- A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.
 - 1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces. Touch up factory-applied finishes where spreaders are removed.
- B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.2 INSTALLATION

- A. Hollow-Metal Frames: Comply with SDI A250.11.
 - 1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces without damage to completed Work.
 - a. Install frames with removable stops located on secure side of opening.
 - 2. Floor Anchors: Secure with post installed expansion anchors.
 - 3. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout or mortar.
 - 4. Installation Tolerances: Adjust hollow-metal frames to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
 - c. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch, measured at jambs at floor.
- B. Hollow-Metal Doors: Fit and adjust hollow-metal doors accurately in frames, within clearances specified below.
 - 1. Non-Fire-Rated Steel Doors: Comply with SDI A250.8.

3.3 CLEANING AND TOUCHUP

- A. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.
- B. Metallic-Coated Surface Touchup: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.
- C. Touchup Painting: Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 08 11 13

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SECTION 08 31 13 - ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes access doors and frames for walls and ceilings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For each type of access door and frame and for each finish specified.
- C. Product Schedule: For access doors and frames.

PART 2 - PRODUCTS

2.1 NOT USED

2.2 ACCESS DOORS AND FRAMES

- A. Flush Access Doors with Exposed Flanges:
 - 1. Description: Face of door flush with frame, with exposed flange and concealed hinge.
 - 2. Locations: Ceiling.
 - 3. Stainless-Steel Sheet for Door: Nominal 0.062 inch, 16 gauge, No. 4 finish.
 - 4. Frame Material: Same finish as door.
 - 5. Latch and Lock Latch bolt, key operated.

2.3 MATERIALS

- A. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304 Remove tool and die marks and stretch lines, or blend into finish.
- B. Frame Anchors: Same material as door face.
- C. Inserts, Bolts, and Anchor Fasteners: Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.

2.4 FABRICATION

- A. Metal Surfaces: For metal surfaces exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.
- B. Doors and Frames: Grind exposed welds smooth and flush with adjacent surfaces. Furnish mounting holes, attachment devices and fasteners of type required to secure access doors to types of supports indicated.
- C. Latch and Lock Hardware:
 - 1. Quantity: Furnish number of latches and locks required to hold doors tightly closed.
 - 2. Keys: Furnish two keys per lock and key all locks alike.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's written instructions for installing access doors and frames.
- B. Adjust doors and hardware, after installation, for proper operation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. No separate measurement will be made for the work of this section.

4.2 PAYMENT

- A. Payment of the work of this section will be included in lump sum payment(s) for the applicable building or facility in accordance with the Schedule of Values.

END OF SECTION 08 31 13

SECTION 08 70 00 - HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes items known commercially as finish or door hardware that are required for swing doors, except special types of unique hardware specified in the same sections as the doors and door frames on which they are installed. All hardware shall be stainless steel.
- B. This section includes the following, but is not necessarily limited to:
 - 1. Door hardware.
 - 2. Power supplies for electric hardware.
 - 3. Thresholds, gasketing and weather-stripping.
 - 4. Door silencers or mutes.
- C. Related Sections: The following sections are noted as containing requirements that relate to this section but may not be limited to this listing.
 - 1. Section 08 11 13 "Hollow Metal Doors and Frames".
 - 2. Section 08 90 00 "Access Doors and Frames".

1.2 REFERENCES

- A. ADAAG - Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities.
- B. BHMA - Builders' Hardware Manufacturers Association.
- C. DHI - Door and Hardware Institute.
- D. NFPA - National Fire Protection Association.
- E. NFPA 80 - Fire Doors and Windows
- F. NFPA 101 - Life Safety Code
- G. NFPA 105 - Smoke and Draft Control Door Assemblies
- H. USBC - Virginia Uniform Statewide Building Code.
- I. WHI - Warnock Hersey Incorporated
- J. SDI - Steel Door Institute

1.3 NOT USED

1.4 SUBMITTALS & SUBSTITUTIONS

- A. General: Submit in accordance with Section 01 33 00, Submittals.
- B. Submit product data (catalog cuts) including manufacturers' technical product information for each item of door hardware, installation instructions, maintenance of operating parts and finish, and other information necessary to show compliance with requirements.
- C. Submit six (6) copies of schedule organized vertically into "Hardware Sets" with index of doors and headings, indicating complete designations of every item required for each door or opening. Include following information:
1. Include a cover sheet with;
 - a. Job name, location, telephone number.
 - b. Engineer's name, location and telephone number.
 - c. Contractor's name, location, telephone number and job number.
 - d. Supplier's name, location, telephone number and job number.
 - e. Hardware consultant's name, location and telephone number.
 2. Job index information included;
 - a. Numerical door number index including; door number, hardware heading number and page number.
 - b. Complete keying information (referred to DHI hand-book "Keying Systems and Nomenclature"). Provision should be made in the schedule to provide keying information when available, if it is not available at the time the preliminary schedule is submitted.
 - c. Manufacturers' names and abbreviations for all materials.
 - d. Explanation of abbreviations, symbols, and codes used in the schedule.
 - e. Mounting locations for hardware.
 - f. Clarification statements or questions.
 - g. Catalog cuts and manufacturer's technical data and instructions.
 3. Vertical schedule format sample:

Heading Number 1 (Hardware group or set number – HW -1)					
			(a) 1 Single Door #1 - Exterior from Elevator Machine Room	(b) 110°	(c) RH
			(d) 3' 0"x7' 0" x 1-3/4" (f) HM		
(g) 1	(h)	(i) ea	(j) Hinges - (k) 5BB1HW 4.5 x 4.5 NRP (l) ½	(m) 626	(n) IVE

			TMS		
2	6AA	1 ea	Lockset - ND50PD x RHO x RH x 10-025 x JTMS	626	SCH

(a) - Single or pair with opening number and location. (b) - Degree of opening. (c) - Hand of door(s) (d) - Door and frame dimensions and door thickness. (e) - Label requirements if any. (f) - Door by frame material. (g) - (Optional) Hardware item line #. (h) - Keyset Symbol. (i) - Quantity. (j) - Product description. (k) - Product Number. (l) - Fastenings and other pertinent information. (m) - Hardware finish codes per ANSI A156.18. (n) - Manufacture abbreviation.

- D. Make substitution requests in accordance with Division 01. Substitution requests must be made prior to bid date. Include product data and indicate benefit to the project. Furnish samples of any proposed substitution.
- E. Wiring Diagrams: Provide product data and wiring and riser diagrams for all electrical products listed in the Hardware Schedule portion of this section.
- F. Keying Schedule: Submit separate detailed schedule indicating clearly how the VRE's final instructions on keying of locks has been fulfilled.
- G. Templates for doors, frames, and other work specified to be factory prepared for the installation of door hardware. Check shop drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.
- H. Furnish as-built/as-installed schedule with close-out documents, including keying schedule, wiring/riser diagrams, manufacturers' installation, adjustment and maintenance information.

1.5 QUALITY ASSURANCE

- A. Obtain each type of hardware (latch and lock sets, hinges, closers, exit devices, etc.) from a single manufacturer.
- B. Supplier Qualifications: A recognized architectural door hardware supplier, with warehousing facilities in the project's vicinity, that has a record of successful in-service performance for supplying door hardware similar in quantity, type, and quality to that indicated for this project and that employs an experienced architectural hardware consultant (AHC) who is available to VRE, Engineer, and Contractor, at reasonable times during the course of the work, for consultation.
 - 1. Responsible for detailing, scheduling and ordering of finish hardware.
 - 2. Meet with VRE to finalize keying requirements and to obtain final instructions in writing.
 - 3. Stock parts for products supplied and be capable of repairing and replacing hardware items found defective within warranty periods.
- C. Hardware Installer: Company specializing in the installation of commercial door hardware with five years documented experience.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Coordinate delivery of packaged hardware items to the appropriate locations (shop or field) for installation.
- B. Hardware items shall be individually packaged in manufacturers' original containers, complete with proper fasteners. Clearly mark packages on outside to indicate contents and locations in hardware schedule and in work.
- C. Provide locked storage area for hardware, protect from moisture, sunlight, paint, chemicals, etc.
- D. Inventory door hardware jointly with representatives of hardware supplier and hardware installer until each is satisfied that count is correct.

1.7 WARRANTY

- A. Provide warranties of respective manufacturers' regular terms of sale from day of final acceptance as follows:
 - 1. Closers: Ten (10) years, except electronic closers shall be two (2) years.
 - 2. All other hardware: Two (2) years.

1.8 MAINTENANCE

- A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for VRE's continued adjustment, maintenance, and removal and replacement of door hardware.

1.9 PRE-INSTALLATION CONFERENCE

- A. Convene a pre-installation conference at least one week prior to beginning work of this section.
- B. Attendance: VRE, Engineer, Construction Manager, Contractor, Security Contractor, Hardware Supplier, Installer, and Project Inspector.
- C. Agenda: Review hardware schedule, products, installation procedures and coordination required with related work. Review master keying requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

	<u>Item</u>	<u>Manufacturer</u>	<u>Acceptable Substitutes</u>
A.	Hinges	Ives	Hager, Stanley, McKinney
B.	Locks, Latches & Cylinders	Schlage	Falcon, Sargent
C.	Closers	LCN	Monarch, Dor-O-Matic
D.	Push, Pulls & Protection Plates	Ives	Trimco, BBW, Quality
E.	Flush Bolts	Ives	Trimco, BBW, Quality
F.	Dust Proof Strikes	Ives	Trimco, BBW, Quality
G.	Stops	Ives	Trimco, BBW, Quality
H.	Thresholds	National Guard	Pemko, Zero
I.	Seals & Bottoms	National Guard	Pemko, Zero

2.2 MATERIALS

- A. Hinges: Exterior out-swinging door butts shall be stainless steel material and shall have stainless steel hinge pins. All doors to have non-rising pins.
1. Hinges shall be sized in accordance with the following:
 - a. Height:
 - 1) Doors up to 41" wide: 4-1/2" inches.
 - 2) Doors 42" to 48" wide: 5 inches.
 - b. Width: Sufficient to clear frame and trim when door swings 180 degrees.
 - c. Number of Hinges: Furnish 3 hinges per leaf to 7'-5" in height. Add one for each additional 2 feet in height.
 2. Furnish non-removable pins (NRP) at all exterior out-swing doors and interior key lock doors with reverse bevels.
- B. Extra Heavy duty Commercial Mortise Locks: Schlage "L" Series as scheduled with "03" Style Lever and "A" Style Rose.

1. Locksets to comply with ANSI A156.13, Series 1000, Operational Grade 1 and Security Grade 1 with all standard trims. Locksets shall also comply with UL10C and UBC 7-2 Positive Pressure requirements
2. Lock case shall be manufactured with heavy 12 gauge steel with fully wrapped design. Lock cases with exposed edges are not acceptable. Lock case shall be multi-functional allowing transformation to a different function without opening lock case.
3. Latch bolt shall have $\frac{3}{4}$ " throw and be non-handed, field reversible without opening the lock case. Solid latch bolts and / or plastic anti-friction devices are not acceptable.
4. The deadbolt, when used, shall be 1" throw stainless steel with a $\frac{3}{4}$ " internal engagement when fully extended.
5. All trim shall be through-bolted with the spring cages supporting the trim attached to the lock cases to prevent torquing.
6. Levers to have independent rotation in both directions. Exterior lever assembly to be one-piece design attached by threaded bushing. Interior lever assembly shall be attached by screwless shank
7. Thru-bolt lever assemblies through the door for positive interlock. Locks using a through the door spindle for attachment are not acceptable. Spindles shall be independent, designed to "break-away" at a maximum of 75psi torque.
8. Hand of lock chassis to be changeable by simply moving one screw from one side to the case to the other and pulling and reversing the latch bolt.
9. Cylinders to be secured by a cast stainless steel, dual retainer. Locks utilizing screws and / or stamped retainers are not acceptable.

C. Closers: LCN as scheduled. Place closers inside building, stairs, room, etc.

1. Door closer cylinders shall be of high strength cast iron construction with double heat treated pinion shaft to provide low wear operating capabilities of internal parts throughout the life of the installation. All door closers shall be tested to ANSI/BHMA A156.4 test requirements by a BHMA certified testing laboratory. A written certification showing successful completion of a minimum of 10,000,000 cycles must be provided.
2. All door closers shall be fully hydraulic and have full rack and pinion action with a shaft diameter of a minimum of 11/16 inch and piston diameter of 1 inch to ensure longevity and durability under all closer applications.
3. All parallel arm closers shall incorporate one piece solid forged steel arms with bronze bushings. 1-9/16" steel stud shoulder bolts, shall be incorporated in regular arms, hold-open arms, arms with hold open and stop built in. All other closers to have forged steel main arms for strength, durability, and aesthetics for versatility of trim accommodation, high strength and long life.
4. All parallel arm closers so detailed shall provide advanced backcheck for doors subject to severe abuse or extreme wind conditions. This advanced backcheck shall be located to begin cushioning the opening swing of the door at approximately 45 degrees. The intensity of the backcheck shall be fully adjustable by tamper resistant non-critical screw valve.
5. Closers shall be installed to permit doors to swing 180 degrees.
6. All closers shall utilize a stable fluid withstanding temperature range of 120 degrees F. to -30 degrees F. without requiring seasonal adjustment of closer speed to properly close the door.
7. Provide the manufactures drop plates, brackets and spacers as required at narrow head rails and special frame conditions. NO wood plates or spacers will be allowed.

8. Maximum effort to operate closers shall not exceed 5 lbs., such pull or push effort being applied at right angles to hinged doors. Compensating devices or automatic door operators may be utilized to meet the above standards. When fire doors are required, the maximum effort to operate the closer may be increased but shall not exceed 15 lbs. when specifically approved by fire marshal. All closers shall be adjusted to operate with the minimum amount of opening force and still close and latch the door. These forces do not apply to the force required to retract latch bolts or disengage other devices that hold the door in a closed position. Door shall take at least 5 seconds to move from an open position of 70 degrees to a point of 3 inches from the latch jamb. Reference 2009 VUSBC Sections 1133B.2.5 & 1133B2.5.1.
9. Provide sex-bolted or through bolt mounting for all door closers.

D. Door Stops:

1. Unless otherwise noted in Hardware Sets, provide wall type with appropriate fasteners. Where wall type cannot be used, provide floor type. If neither can be used, provide overhead type.
2. Do not install floor stops more than 4 inches from the face of the wall or partition (2009 IBC Section 1133B.8.6).
3. Overhead stops shall be made of stainless steel and non-plastic mechanisms and finished metal end caps. Field-changeable hold-open, friction and stop-only functions.

E. Protection Plates: Fabricate either kick, armor, or mop plates with four beveled edges. Provide kick plates 10 inches high and 2 inches LDW. Sizes of armor and mop plates shall be listed in the Hardware Schedule. Furnish with machine or wood screws of bronze or stainless to match other hardware.

F. Thresholds: As Scheduled and per details.

1. Thresholds shall not exceed 1/2 inch in height, with a beveled surface of 1:2 maximum slope.
2. Set thresholds in a full bed of butyl-rubber or polyisobutylene mastic sealant complying with requirements in Division 07.
3. Use 1/4 inch fasteners, red-head flat-head sleeve anchors (SS/FHSL).
4. Thresholds shall comply with 2009 VUSBC Section 1133B.2.4.1.

G. Silencers: Furnish silencers for interior hollow metal frames, 3 for single doors, 2 for pairs of doors. Omit where sound or light seals occurs, or for fire-resistive-rated door assemblies.

2.3 KEYING

- A. Furnish a Grand Master, Master, keyed alike or keyed different system as directed by the VRE.
- B. Provide construction keying for doors requiring locking during construction; remove temporary cores or inserts immediately prior to VRE occupancy. Furnish permanent keys (and cores if applicable) directly to VRE.
- C. Key Blanks: Standard "6" pin bow key blank; tag to identify.

D. Supply keys and blanks as follows:

1. Supply 2 cut change keys for each different change key code.
2. Supply 1 uncut key blank for each change key code.
3. Supply 6 cut master keys for each different master key set.
4. Supply 3 uncut key blanks for each master key set.

2.4 FINISHES

- A. To be satin stainless steel SST US32D (630) unless otherwise noted.
- B. Furnish push plates, pull plates and kick or armor plates in satin stainless steel US32D (630) unless otherwise noted.
- C. Aluminum items to be finished anodized aluminum except thresholds which can be furnished as standard mill finish.

2.5 FASTENERS

- A. Screws for strikes, face plates and similar items shall be stainless steel flat head, countersunk type, provide machine screws for metal.
- B. Screws for butt hinges shall be flathead, countersunk, full-thread type.
- C. Fastening of closer bases or closer shoes to doors shall be by means of sex bolts and spray painted to match closer finish.
- D. Provide expansion anchors for attaching hardware items to concrete or masonry.
- E. All exposed fasteners shall have a tamper resistant heads. Fasteners not exposed shall be of the Phillips type.
- F. Finish of tamper resistant screws and other screws shall match surface finish of hardware or other adjacent work.
- G. All door closers and Lock Protectors shall be fastened to the door by the means of sex bolts or through bolts.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Verify that doors and frames are square and plumb and ready to receive work and dimensions are as instructed by the manufacturer.
- B. Beginning of installation means acceptance of existing conditions.

3.2 INSTALLATION

- A. Install hardware in accordance with manufacturer's instructions and requirements of DHI.
- B. Use the templates provided by hardware item manufacturer.
- C. Mounting heights for hardware shall be as recommended by the Door and Hardware Institute. Operating hardware will to be located between 30 inches and 44 inches AFF.
- D. Set units level, plumb and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.
- E. Drill and countersink units that are not factory-prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.
- F. Set thresholds for exterior doors in full bed of butyl-rubber sealant.
- G. If hand of door is changed during construction, make necessary changes in hardware at no additional cost.
- H. Hardware Installer shall also be present with the security contractor when the power is turned on for the testing of the electronic hardware applications. Installer shall make adjustments to solenoids, latches, vertical rods and closers to insure proper and secure operation. .
- I. Conductors shall be minimum 18 gage stranded, multicolored. A minimum 12 in. loop of conductors shall be coiled in the interface junction box. Each conductor shall be permanently marked with its function.
- J. If a power supply is specified in the hardware sets, all conductors shall be terminated in the power supply. Make all connections required for proper operation between the power supply and the electro-mechanical hardware. Provide the proper size conductors as specified in the manufacturer's technical documentation.

3.3 ADJUST AND CLEAN

- A. Adjust and check each operating item of hardware and each door, to ensure proper operation or function of every unit. Replace units which cannot be adjusted to operate freely and smoothly as intended for the application made.
- B. Clean adjacent surface soiled by hardware installation.
- C. Final Adjustment: Wherever hardware installation is made more than one month prior to acceptance or occupancy, return to that work area and make final check and adjustment of all hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.
- D. Instruct VRE's personnel in proper adjustment and maintenance of hardware finishes, during the final adjustment of hardware.
- E. Continued Maintenance Service: Approximately six months after the completion of the project, the Contractor accompanied by the Architectural Hardware Consultant, shall return to the project and re-adjust every item of hardware to restore proper functions of doors and hardware. Consult with and instruct VRE's personnel in recommended additions to the maintenance procedures. Replace hardware items which have deteriorated or failed due to faulty design, materials or installation of hardware units. Prepare a written report of current and predictable problems (of substantial nature) in the performance of the hardware.

3.4 HARDWARE LOCATIONS

- A. Conform to ADAAG for positioning requirements for the disabled.

3.5 FIELD QUALITY CONTROL

- A. Architectural Hardware Consultant (AHC) to inspect installation and certify that hardware and its installation have been furnished and installed in accordance with manufacturer's instructions and as specified herein.

3.6 SCHEDULE

- A. The items listed in the following schedule shall conform to the requirements of the foregoing specifications.
- B. The Door Schedule on the Drawings indicates which hardware set is used with each door.

Manufacturers Abbreviations (Mfr.)

ADA	=	Adams Rite Mfg.	Aluminum Door Hardware
GLY	=	Glynn-Johnson Corporation	Overhead Door Stops
IVE	=	Ives	Hinges, Pivots, Bolts, Coordinators, Dust Proof Strikes, Push Pull & Kick Plates, Door Stops & Silencers
LCN	=	LCN	Door Closers
NGP	=	National Guard Products	Thresholds, Gasketing & Weather-stripping
SCH	=	Schlage Lock Company	Locks, Latches & Cylinders
TRI	=	Trimco	Cane Bolts
VON	=	Von Duprin	Exit Devices

HARDWARE**SET:****01**

3	Ea	Hinge	5BB1 4.5 X 4.5 NRP	630	IVE
1	Ea	Storeroom Lock	ND80TD SPA	626	SCH
1	Ea	FSIC Core	23-030	626	SCH
1	Ea	Electric Strike	6211 FSE DSLC	630	VON
1	Ea	Surface Closer	4040XP	689	LCN
1	Ea	Kick Plate	8400 10" X 2" LDW	630	IVE
1	Ea	Mop Plate	8400 4" x 1" LDW	630	IVE
1	Ea	Wall Stop	WS407CCV	630	IVE
1	Set	Door Seal	797B	BLK	REE
1	Ea	Door Sweep	DB594A	AL	REE
1	Ea	Non-Slip Threshold	803V	AL	NGP

Note: operation of opening- door normally closed and locked. Door unlocked during access control system time zone. Free egress at all times. Upon loss of power, door remains locked (fail secure).

PART 4 - MEASUREMENT AND PAYMENT**4.1 MEASUREMENT**

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 08 70 00

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SECTION 08 90 00 - LOUVERS AND VENTS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fixed, formed metal louvers.
2. Accessories required for a complete installation.

B. Related Sections:

1. Section 09 91 13 “Exterior Painting”
2. Section 23 05 29 “Hangers and Supports for HVAC Piping”
3. Section 23 09 23.01 “Electrical Work”
4. Section 23 33 00 “Air Duct Accessories”

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Exterior metal louvers capable of withstanding effects of loads and stresses from wind and normal thermal movement without evidencing permanent deformation of louver components including blades, frames, and supports; noise or metal fatigue caused by louver blade rattle or flutter; or permanent damage to fasteners and anchors.

1. Wind Load: Uniform pressure (velocity pressure) of 30 lbf/sq. ft., acting inward or outward.
2. Thermal Movements: Louvers allowing for thermal movements resulting from maximum change (range) of 120 deg F and 180 deg F in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, and other detrimental effects:

B. Air Performance, Water Penetration, and Air Leakage Ratings: Louvers complying with performance requirements indicated, demonstrated by testing manufacturer's stock units 48 inches wide by 48 inches high. Test units according to AMCA 500L.

1. Perform testing on unpainted, cleaned, degreased units.
2. Perform water penetration testing on louvers without screens.

C. Airborne Sound Transmission Loss: Acoustical louvers complying with airborne sound transmission loss ratings indicated, demonstrated by testing stock units according to ASTM E90.

1.4 ACTION SUBMITTALS

A. Make submittals in accordance with Section 01 33 00, Submittals.

- B. Product Data: Technical data, installation recommendations, required accessories, and pertinent data for each type of louver or vent required.
- C. Shop Drawings: For louver units and accessories, submit plans; elevations; sections; and details showing profiles, angles, and spacing of louver blades. Show unit dimensions related to wall openings and construction; free area for each size indicated; profiles of frames at jambs, heads, and sills; and anchorage details and locations.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. SMACNA Standard: Comply with SMACNA's Architectural Sheet Metal Manual recommendations for fabrication, construction details, and installation procedures.
- B. Single Source Responsibility: Obtain louvers and vents from a single source where alike in one or more respects with regard to type, design, and factory applied color finish.

1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on shop drawings. Coordinate fabrication schedule with construction progress to avoid delaying work.
 - 1. Established Dimensions: Where field measurements cannot be made without delaying work, establish opening dimensions and proceed with fabricating louvers without field measurements. Coordinate construction to ensure that actual opening dimensions correspond to established dimensions.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Product Requirements.

2.2 MATERIALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or equal approved as a comparable product:
 - 1. Airo-lite Co.
 - 2. American Warming and Ventilating, Inc., div. Mestek.
 - 3. C/S Group.
 - 4. Industrial Louvers, Inc.
 - 5. Ruskin Company.
 - 6. Greenheck
- B. Formed Aluminum louvers

- C. Fasteners: Same basic metal and alloy fastened metal or 300 series stainless steel, unless otherwise indicated. Do not use metals incompatible with joined materials.
 - 1. Use types and sizes to suit unit installation conditions.
 - 2. Use Tamper Proof flat head screws for exposed fasteners, unless otherwise indicated.
- D. Anchors and Inserts: Of type, size, and material required for loading and installation indicated. Use nonferrous metal or hot dip galvanized anchors and inserts for exterior installations and elsewhere as needed for corrosion resistance. Use toothed steel or expansion bolt devices for drilled in place anchors.
- E. Bituminous Paint: Cold applied asphalt mastic complying with SSPC-Paint 33 but containing no asbestos fibers, or cold applied asphalt emulsion complying with ASTM D1187.

2.3 FABRICATION

- A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
- B. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
- C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining materials' tolerances, and perimeter sealant joints.
 - 1. Frame Type: Channel type, unless otherwise indicated.
- D. Provide supports, anchorages, and accessories required for complete assembly.
- E. Provide vertical mullions of type and at spacings recommended by manufacturer, or 72 inches o.c., whichever is less. At horizontal joints between louver units, provide horizontal mullions, unless continuous vertical assemblies are indicated.
- F. Provide sill extensions and loose sills made of same material as louvers where required for drainage to exterior and to prevent water penetrating to interior.
- G. Join frame members to one another and to fixed louver blades with fillet welds concealed from view or size of louver assembly makes bolted connections between frame members necessary.
- H. Fixed, Formed Aluminum Louvers: Provide louvers with frames and blades formed from metal sheet of metal indicated. Provide fixed louvers as indicated on Drawings.
 - 1. Horizontal Louvers: Storm-proof drainable blade type:
 - a. Louver Depth (Fixed): 4 inches.
 - b. Frame and Blade Material: .080 aluminum

- c. Blade Angle and Spacing: 45 degrees and 4 inches (100 mm) o.c. for 4 inch deep louvers.
 - d. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
 - e. Screening Type: Provide insect screening.
2. Continuous, Horizontal, Drainable Blade Storm-proof type Louvers: Fabricated with close fitting, field made splice joints in blades designed to permit expansion and contraction without deforming blades or framework and with mullions recessed from front edges of blades, so blades have continuous appearance.

2.4 FINISHES

- A. Comply with NAAMM's Metal Finishes Manual for Architectural and Metal Products for recommendations for applying and designating finishes.
- B. Finish louvers after assembly.
- C. Aluminum Finishes: Match finish of manufactured wall panels for an uninterrupted appearance.
 - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A780. Apply a conversion coating of type suited to organic coating applied over it.
 - 3. Kynar-type Finish: Paint immediately after cleaning and pre-treating. Confirm manufacturer's instructions to achieve a minimum dry film thickness of 2.0 mils.
 - a. Color and Gloss: Selected by Architect.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of anchorages to project site.

3.2 INSTALLATION

- A. Locate and place louver units level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.

- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so that no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- G. Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses, where weather-tight louver joints are required. Comply with Section 07 90 00, Joint Protection, for sealants applied during louver installation.

3.3 CLEANING AND PROTECTING

- A. Periodically clean exposed surfaces of louvers and vents that are not protected by temporary covering to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.
- B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- C. Protect louvers and vents from damage during construction. Use temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at the time of Substantial Completion.
- D. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Engineer, remove damaged units and replace with new units.
 - 1. Clean and touch up minor abrasions in finishes with air dried coating that matches color and gloss of, and is compatible with, factory applied finish coating.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 08 90 00

SECTION 091000 - TACTILE/DETECTABLE WARNING SURFACE TILE AND STRIPING

TAPE

PART 1 – GENERAL

1.1 SUMMARY:

- A. Requirements for furnishing and installing surface applied detectable warning surface tile, in an inline dome pattern on ramps and platform surfaces as indicated on the contract drawings.
- B. Section 03 30 00 – Cast-in-Place Concrete

1.2 ACTION SUBMITTALS

- A. Product data for each specified product per Section 01300.
- B. Shop drawings, showing detailed plans of tile and striping tape profile, and installation methods
- C. Two (2) tile samples, minimum size 6" x 8" of the kind proposed for use.
- D. Two (2) striping tape samples, minimum size 3" x 8" of the kind proposed for use.
- E. Material Test Reports: Submit test reports from qualified independent testing laboratory indicating that materials proposed for use are in compliance with requirements and meet the properties indicated. All test reports shall be conducted on a wet concrete tactile panel system as certified by a qualified independent testing laboratory.
- F. Maintenance Instructions: Submit copies of manufacturer's specified maintenance practices for each type of tactile tile, tape and accessory as required.

1.3 INFORMATIONAL SUBMITTALS

- A. Product certificates.
- B. Product test reports.
- C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.5 WARRANTY

- A. Installed tiles and striping tape shall be warranted for a minimum of five (5) years against failure of adhesives, fasteners and sealants.

PART 2 – PRODUCTS**2.1 PERFORMANCE REQUIREMENTS:**

- A. American Society for Testing and Materials (ASTM):

1. B117 Test Method of Salt Spray (Fog) Testing
2. C501 Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser
3. C1026 Test Method for Measuring the Resistance of Ceramic Tile to Freeze-Thaw Cycling
4. C1028 Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other like Surfaces by the Horizontal Dynamometer Pull Method
5. D543 Test Method for Resistance of Plastics to Chemical Reagents
6. D570 Test Method for Water Absorption of Plastics
7. D638 Test Method for Tensile Properties of Plastics
8. D790 Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
9. D695 Test Method for Compressive Properties of Rigid Plastics

- B. Americans with Disabilities Act (ADA):

Provide tactile warning surfaces, which comply with the detectable warnings on walking surfaces, section of the Americans with Disabilities Act (Title 49 CFR TRANSPORTATION, PART 37.9 STANDARDS FOR ACCESSIBLE TRANSPORTATION FACILITIES, Appendix A, Section 4.29.2 DETECTABLE WARNINGS ON WALKING SURFACES).

2.2 TILES:

- A. ADA and CCR compliant; a homogenous glass and carbon reinforced composite which is colorfast and UV stable with fiberglass reinforced truncated domes for enhanced durability. The tile shall incorporate an in-line dome pattern of truncated domes 0.2" in height, 0.9" diameter at the base, and 0.4" diameter at top of dome spaced 2.35" nominal as measured side by side. The tile shall be installed with six countersunk fastening holes, and perimeter beveled edges. For wheelchair safety the field area shall consist of a non-slip surface with a minimum of 40 - 90° raised points 0.045" high, per square inch; Replaceable (Wet – Set) Composite Tactile as manufactured by ADA Solutions, Inc., Tel: 800-372- 0519, or approved equal.

1. Color: Safety Yellow, (Federal Color # 33538) colorfast, UV stabilized coating. The color is uniform throughout and does not rely on any type of paint coating to achieve color stability.

2. Size: 24" minimum- 24" x 60" x 3/8" nominal

- B. Performance: Tiles shall meet or exceed the following criteria:

1. Water Absorption: 0.35% maximum, when tested in accordance with ASTM D570.
2. Slip Resistance: 0.90 minimum combined wet/ dry static coefficient of friction on top of domes and field area, when tested in accordance with ASTM C1028.
3. Compressive Strength: 28,900 psi minimum, when tested in accordance with ASTM D695.
4. Tensile Strength: 11,600 psi minimum, when tested in accordance with ASTM D638.
5. Flexural Strength: 29,300 psi minimum, when tested in accordance with ASTM C790.
6. Gardner Impact: 450 inch-pounds per inch minimum, when tested in accordance with Geometry "GE" of ASTM D5420.
7. Chemical Stain Resistance: No reaction to 1% hydrochloric acid, urine, calcium chloride, stamp pad ink, gum and red aerosol paint, when tested in accordance with ASTM D543.
8. Wear Depth: 0.03" maximum, after 1000 abrasion cycles of 40 grit Norton Metallite sandpaper, when tested in accordance with ASTM C501.
9. Flame Spread: 20 maximum, when tested in accordance with ASTM E84.

10. Accelerated Weathering: No deterioration, fading or chalking for 2000 hours, when tested in accordance with ASTM G155.
- C. Tactile warning tiles adhered to concrete shall meet or exceed the following performance criteria:
1. Accelerated Aging and Freeze Thaw of Adhesive System: No cracking, delamination, warping, checking, blistering, color change, loosening, etc. when tested in accordance with ASTM C1026.
 2. Salt and Spray Performance: No deterioration after 200 hours of exposure, when tested in accordance with ASTM B117.

2.3 STRIPING TAPE AND STENCILING:

- A. Plastic-Backed Preformed Tape Pavement Marking Material VDOT Type B, Class IV: Plastic - backed preformed tape shall conform to the requirements of ASTM D4505 for a Type I or VI, Grade B, C, D, or E, material and any additions and/or exceptions indicated herein. Tape shall be suitable for use on hydraulic cement concrete surfaces and shall be capable of being applied to previously apply marking material of the same composition under normal conditions of use. Tape shall be selected from VDOT approved products list.
1. Thickness (no adhesive): The thickness shall be at least 60 mils and no more than 90 mils.
 2. Skid resistance: Skid resistance requirements for a Type I material shall be the same as those for a Type VI material.
 3. Initial retro-reflectivity: Initial retro-reflectivity requirements for a Type VI material shall be the same as those for a Type I material.
 4. Maintained retro-reflectivity, durability and adhesion: Maintained retro-reflectivity, durability, and adhesion shall conform to the following requirements after being installed on the test deck for 1 year:
 - a. Maintained retro-reflectivity: The photometric quantity to be measured is the coefficient of retro-reflected luminance (RL) in accordance with the requirements of ASTM E1743 for 15-meter geometry and ASTM E1710 for 30-meter geometry. RL shall be expressed in milli-candelas per square foot per foot-candle and shall be at least either 150 for 15-meter or 100 for 30-meter when measured in the skip line or centerline areas.
 - b. Durability: Tape shall have a durability rating of at least 4.

- c. Adhesion: No line shall be displaced, be torn or missing.

- B. Polyester-Resin Pavement Marking Material VDOT Type B, Class II: Polyester-resin is a two-component pavement marking material suitable for use on hydraulic cement concrete surfaces.

1. Composition (un-catalyzed material):

	3	Min.	Max.
nent	6	36.0	40.0
ylic monomer	9	8.5	—
Polyester resin		—	55.5

2. Physical requirements (uncatalyzed material):

- a. Viscosity: Viscosity (25 degrees C) determined in accordance with the requirements of ASTM D562 shall be 80 to 90 Krieb units.
- b. Weight per gallon: The weight per gallon shall be at least 11.5 pounds.
- c. Drying time: The catalyst/resin ratio shall be adjusted by the operator so that the applied line shall dry to a no-tracking condition in 15 minutes or less when applied at an application temperature of 77 degrees F to 100 degrees F, a substrate temperature of at least 60 degrees F, a wet thickness of 15 to 25 mils, and with 10 to 15 pounds of glass beads conforming to the requirements of VDOT Section 234 applied per gallon.
- d. Catalyst: The catalytic component of the system shall be a commercially available type recommended by the manufacturer of the polyester. The peroxide shall not be exposed to any form of heat, such as direct sunlight, radiators, open flame, or sparks as heat may cause the organic peroxide to decompose violently or burn if ignited. The peroxide shall not come into contact with easily oxidized metals, such as copper, brass, mild steel, or galvanized steel as this can also initiate a violent reaction.
- e. Weight loss: Beaded catalyzed material shall have a weight loss of not more than 125 milligrams after 1,000 revolutions when abraded in accordance with the requirements of Federal Test Method Standard No. 141b, Method 6192, and using CS-17 wheels with a 1,000-gram load on each wheel.
- f. Shelf life: The shelf life of un-catalyzed material shall be at least 6 months when stored in a cool area below 85 degrees F.
- g. Durability and wear resistance: Material shall be designed to provide a life expectancy of at least 5 years under average daily passenger

traffic.

- h. Hiding: The marking shall show a dry hiding quality that will yield a contrast ratio of at least 0.96 with the Morest Black and White Power Chart, Form 03B, when drawn down at a 15-mil wet film thickness. Readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931, 2 degrees standard observer and CIE standard Illuminant D65.

PART 3 – EXECUTION

10.1 PREPARATION:

- A. Furnish products as indicated.
- B. Ensure substrates are in suitable condition to receive work of this Section.

10.2 INSTALLATION:

- A. Ensure that surfaces being prepared and fabricated to receive the tiles and striping tape are constructed and prepared correctly and adequately for tile installation.
- B. Immediately prior to installing the detectable warning surface tile and striping tape, the concrete surfaces must be inspected to ensure that they are as specified in the contract documents while maintaining a slump range of 4-7 inches to permit the solid placement of the ADA Replaceable Composite (Wet-Set) Tactile Unit (ADAREP) in the wet cement.
- C. Install the ADAREP units per the manufacturer's instructions.
- D. Plastic-backed preformed tape shall be installed in accordance with the manufacturer's recommendations and as denoted herein. Tape shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Primer/adhesive shall be used for all installations except when tape is applied immediately following the final rolling of the new asphalt concrete surface and shall be from the same manufacturer as the tape. Tape for pavement line markings shall be applied by an application cart as recommended by the manufacturer. Tape shall be tamped into place with a tamper cart with the weight as recommended by the manufacturer.
- E. Polyester resin material shall be applied only on hydraulic cement concrete pavements. Polyester resin shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Polyester resin may be applied over existing polyester resin markings. Glass beads shall be applied to the surface at the rate of 8 pounds per gallon of material.

PART 4 - MEASUREMENT AND PAYMENT**4.1 MEASUREMENT**

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 091000

SECTION 09 29 00 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior gypsum board.

B. Related Sections:

1. Section 07 21 00, "Thermal Insulation", for insulation installed in assemblies that incorporate gypsum board.
2. Section 07 92 00, "Joint Sealants", for sealants used in gypsum board assemblies.
3. Section 09 91 13, "Exterior Painting", for primers applied to gypsum board surfaces.

1.2 NOT USED

1.3 NOT USED

1.4 SUBMITTALS

- A. Make submittals in accordance with Section 01 33 00, Submittal Procedures.
- B. Product Data: For each type of product indicated.

1.5 QUALITY ASSURANCE

- A. Health Protection: Provide materials made in the U.S.

1.6 STORAGE AND HANDLING

- A. Store materials inside under cover and keep them dry and protected against damage from weather, condensation, direct sunlight, construction traffic, and other causes. Stack panels flat to prevent sagging.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Comply with ASTM C840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.
- B. Do not install interior products until installation areas are enclosed and conditioned.
- C. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or blotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products or substitutions in accordance with Section 01 60 00, Products.

2.2 PANELS, GENERAL

- A. Size: Provide in maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.3 INTERIOR GYPSUM BOARD

- A. General: Complying with ASTM C36 or ASTM C1396, as applicable to type of gypsum board indicated and whichever is more stringent.
 1. Manufacturers: Subject to compliance with requirements, manufacturers whose products may be incorporated into the work include, but are not limited to:
 - a. G-P Gypsum.
 - b. National Gypsum Company.
 - c. USG Corporation.
- B. Moisture- and Mold-Resistant Type (AKA "Moisture Resistant", where noted on the drawings): With moisture- and mold-resistant core and surfaces.
 2. Core: 1/2".
 3. Long Edges: Tapered.
 4. Sag-Resistant Type: Use for horizontal applications, as at ceilings.
 5. Mold Resistance: Mold resistance rating of 10 when tested in accordance with ASTM D 3273 and evaluated in accordance with ASTM D 3274.
 6. Product Type: One of the following:
 - a. Glass mat water-resistant gypsum panel, with glass mat facings and water-resistant fiber-reinforced gypsum core, complying with ASTM C1658; Georgia-Pacific DensArmor Plus High-performance Interior Panels, or equal approved as a substitution.

- b. Fiber-reinforced, water-resistant gypsum panel, unfaced with water-resistant core, complying with ASTM C1278; US Gypsum Fiberock Aqua-Tough Interior Gypsum Panel, or equal approved as a substitution.
- c. Gypsum panel with paper faces treated with an antimicrobial agent and containing core additives to add resistance to mold, mildew, and moisture, complying with ASTM C1396; National Gypsum Gold Bond Gypsum Wallboard, or equal approved as a substitution.
- d. Traditional water-resistant gypsum board (green board) shall not be used.

2.4 TRIM ACCESSORIES

A. Interior Trim: ASTM C1047.

- 1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.
- 2. Shapes:
 - a. Cornerbead.
 - b. "J" mold or edge casing.

2.5 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C475.

B. Joint Tape:

- 3. Interior Gypsum Wallboard: Paper.
- 4. For Mold, Mildew, and Moisture Resistant Board: Mold and mildew resistant tape as recommended by board manufacturer.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

- 5. Prefilling: At open joints and damaged surface areas, use setting-type taping compound.
- 6. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.
- 7. Use setting-type compound for installing paper-faced metal trim accessories.
- 8. Fill Coat: For second coat, use setting-type, sandable topping compound.
- 9. Finish Coat: For third coat, use setting-type, sandable topping compound.
- 10. Skim Coat: For final coat of Level 5 finish, use setting-type, sandable topping compound.

- D. Joint Compound for Mold, Mildew, and Moisture Resistant Board: Mold and mildew resistant compound as recommended by board manufacturer.

2.6 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.
- B. Steel Drill Screws: ASTM C1002, unless otherwise indicated.
 - 1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.
- C. Sealant: As specified in Section 07 92 00, Joint Sealants.
- D. Thermal Insulation: As specified in Section 07 21 00, Thermal Insulation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and substrates, with installer present, and including welded hollow-metal frames and framing, for compliance with requirements and other conditions affecting performance.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLYING AND FINISHING PANELS, GENERAL

- A. Comply with ASTM C840.
- B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
- C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.
- D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
- E. Form control and expansion joints with space between edges of adjoining gypsum panels.

- F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
 - 1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. in area.
 - 2. Fit gypsum panels around ducts, pipes, and conduits.
 - 3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch-wide joints to install sealant.
- G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments, except floors. Provide 1/4- to 1/2-inch-wide spaces at these locations, and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant in accordance with ASTM C919.
- H. Attachment to Steel Framing: Attach panels so that leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

3.3 APPLYING INTERIOR GYPSUM BOARD

- A. Install interior gypsum board in the following locations:
 - 1. Moisture- and Mold-Resistant Type: Wet, damp, restrooms, behind and adjacent to kitchenette sink.
- B. Single-Layer Application:
 - 1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing, unless otherwise indicated.
 - 2. On partitions/walls, apply gypsum panels vertically (parallel to framing), unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
 - a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
 - b. At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.
 - 3. On Z-furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
 - 4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

3.4 INSTALLING TRIM ACCESSORIES

- A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
- B. Interior Trim: Install in the following locations:
 - 1. Cornerbead: Use at outside corners.

3.5 FINISHING GYPSUM BOARD

- A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
- B. Prefill open joints and damaged surface areas.
- C. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.
- D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:
 - 1. Level 4: At all panel surfaces, unless otherwise indicated.

3.6 APPLYING TEXTURE FINISHES

- A. Surface Preparation and Primer: Prepare and apply primer to gypsum panels and other surfaces receiving texture finishes. Apply primer to surfaces that are clean, dry, and smooth.
- B. Texture Finish Application: Verify texture with Engineer prior to application. Mix and apply finish using powered spray equipment, to produce a uniform texture free of starved spots or other evidence of thin application or of application patterns.
- C. Prevent texture finishes from coming into contact with surfaces not indicated to receive texture finish by covering them with masking agents, polyethylene film, or other means. If, despite these precautions, texture finishes contact these surfaces, immediately remove droppings and overspray to prevent damage according to texture-finish manufacturer's written recommendations.
- D. Glass-mat moisture resistant gypsum board panels shall receive skim coat over entire exposed surface for smooth finish.

3.07 PROTECTION

- A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- B. Remove and replace panels that are wet, moisture damaged, and mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 09 29 00

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SECTION 09 91 13 - EXTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes surface preparation and the application of paint systems on the following exterior substrates:
 - 1. Concrete.
 - 2. Concrete masonry units (CMUs).
 - 3. Steel and iron.
 - 4. Galvanized metal. (Unless otherwise noted – See Pedestrian Bridge Structural Sheets)
- B. Related Requirements:
 - 1. Section 051200 "Structural Steel Framing" for shop priming of metal substrates.
 - 2. Section 055000 "Metal Fabrications" for shop priming metal fabrications.
 - 3. Section 055113 "Metal Pan Stairs" for shop priming metal pan stairs.
 - 4. Section 055213 "Pipe and Tube Railings" for shop priming and painting pipe and tube railings.
 - 5. Section 099600 "High-Performance Coatings" for additional painting requirements.

1.3 DEFINITIONS

- A. MPI Gloss Level 1: Not more than five units at 60 degrees and 10 units at 85 degrees, according to ASTM D523.
- B. MPI Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D523.
- C. MPI Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D523.
- D. MPI Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D523.
- E. MPI Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D523.
- F. MPI Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D523.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
 - 1. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
 - 2. Indicate VOC content.
- B. Sustainable Design Submittals:
 - 1. Product Data: For paints and coatings, indicating VOC content.
- C. Samples for Initial Selection: For each type of topcoat product.
- D. Samples for Verification: For each type of paint system and each color and gloss of topcoat.
 - 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
 - 2. Apply coats on Samples in steps to show each coat required for system.
 - 3. Label each coat of each Sample.
 - 4. Label each Sample for location and application area.
- E. Product List: Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include color designations.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Paint: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.6 QUALITY ASSURANCE

- A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 - 1. Architect will select one surface to represent surfaces and conditions for application of each paint system.
 - a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
 - b. Other Items: Architect will designate items or areas required.
 - 2. Final approval of color selections will be based on mockups.
 - a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 1. Maintain containers in clean condition, free of foreign materials and residue.
 2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Benjamin Moore & Co.
 2. PPG Paints.
 3. Sherwin-Williams Company (The).

2.2 PAINT, GENERAL

- A. MPI Standards: Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products Lists."
- B. Material Compatibility:
 1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

- C. VOC Content: For field applications, paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
 - 1. Flat Paints and Coatings: 50 g/L.
 - 2. Nonflat Paints and Coatings: 50 g/L.
 - 3. Dry-Fog Coatings: 150 g/L.
 - 4. Primers, Sealers, and Undercoaters: 100 g/L.
 - 5. Rust-Preventive Coatings: 100 g/L.
 - 6. Zinc-Rich Industrial Maintenance Primers: 100 g/L.
 - 7. Pretreatment Wash Primers: 420 g/L.
 - 8. Shellacs, Clear: 730 g/L.
 - 9. Shellacs, Pigmented: 550 g/L.
- D. Colors: As indicated in a color schedule.

2.3 SOURCE QUALITY CONTROL

- A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:
 - 1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
 - 2. Testing agency will perform tests for compliance with product requirements.
 - 3. Owner may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 - 1. Concrete: 12 percent.
 - 2. Gypsum Board: 12 percent.
- C. Exterior Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
- D. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

- E. Proceed with coating application only after unsatisfactory conditions have been corrected.
 - 1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.
- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
- D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.
- E. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
 - 1. SSPC-SP 2.
 - 2. SSPC-SP 3.
 - 3. SSPC-SP 7/NACE No. 4.
 - 4. SSPC-SP 11.
- F. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- G. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

3.3 APPLICATION

- A. Apply paints according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
 - 1. Use applicators and techniques suited for paint and substrate indicated.
 - 2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.

3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
 4. Paint entire exposed surface of window frames and sashes.
 5. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 6. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- B. Tint undercoats same color as topcoat, but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
1. Paint the following work where exposed to view:
 - a. Equipment, including panelboards and switch gear.
 - b. Uninsulated metal piping.
 - c. Uninsulated plastic piping.
 - d. Pipe hangers and supports.
 - e. Metal conduit.
 - f. Plastic conduit.
 - g. Tanks that do not have factory-applied final finishes.

3.4 FIELD QUALITY CONTROL

- A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
1. Contractor shall touch up and restore painted surfaces damaged by testing.
 2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 EXTERIOR PAINTING SCHEDULE

A. Concrete Substrates, Exterior Nontraffic Surfaces:

1. Epoxy System MPI EXT 3.1D:

- a. Prime Coat: Epoxy, matching topcoat.
- b. Intermediate Coat: Epoxy, matching topcoat.
- c. Topcoat: Two part epoxy, solvent based, acid resistant, high gloss (MPI Gloss Level 6), MPI #77.

B. Concrete Substrates, Interior Traffic Surfaces:

1. Epoxy Floor Paint System MPI INT 3.2C:

- a. Prime Coat: Floor paint, epoxy, matching topcoat.
- b. Intermediate Coat: Floor paint, epoxy, matching topcoat.
- c. Topcoat: Floor paint, epoxy, slip resistant additive, low gloss (maximum MPI Gloss Level 3), MPI #77.

C. CMU Substrates, Interior Nontraffic Surfaces:

1. Epoxy High Build System MPI EXT 4.2R:

- a. Prime Coat: Block filler, epoxy, solvent based, high solids, alkali resistant, interior/exterior, MPI #116.
- b. Intermediate Coat: Epoxy, exterior, matching topcoat.
- c. Topcoat: Epoxy, exterior, high solids, flat (MPI Gloss Level 1), MPI #108.

D. Steel and Iron Substrates – Structural Steel and Metal Fabrications:

1. High Build Self-priming Epoxy System MPI EXT 5.1S:

- a. Prime Coat: Epoxy, High Build, Self-priming, low gloss, MPI #120.
- b. Intermediate Coat: Epoxy, matching topcoat.
- c. Topcoat: Two part epoxy, solvent based, acid resistant, gloss (MPI Gloss Level 5), MPI #77.

E. Galvanized-Metal Substrates – Stairs, Steel, Doors, Frames, Railings, Pipes, Decking, Gutters:

1. Epoxy System MPI EXT 5.3C:

- a. Prime Coat: Primer, galvanized, water based, MPI #101.
- b. Intermediate Coat: Epoxy, exterior, matching topcoat.
- c. Topcoat: Epoxy, exterior, semi-gloss (MPI Gloss Level 5), MPI #177.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 099113

SECTION 099600 - HIGH-PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes surface preparation and the application of high-performance coating system on the following substrates:
 - 1. Exterior Substrates:
 - a. Steel.
 - b. Galvanized metal.
- B. Related Requirements:
 - 1. Section 051200 "Structural Steel Framing" for shop priming of structural steel with primers specified in this Section.

1.3 DEFINITIONS

- A. MPI Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D523.
- B. MPI Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D523.
- C. MPI Gloss Level 7: More than 85 units at 60 degrees, according to ASTM D523.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
 - 1. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
 - 2. Indicate VOC content.
- B. Sustainable Design Submittals:
 - 1. Product Data: For paints and coatings, indicating VOC content.

2. Laboratory Test Reports: For paints and coatings, indicating compliance with requirements for low-emitting materials.
- C. Samples for Initial Selection: For each type of topcoat product indicated.
- D. Samples for Verification: For each type of coating system and each color and gloss of topcoat indicated.
 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
 2. Apply coats on Samples in steps to show each coat required for system.
 3. Label each coat of each Sample.
 4. Label each Sample for location and application area.
- E. Product List: Cross-reference to coating system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include color designations.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Coatings: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.6 QUALITY ASSURANCE

- A. Mockups: Apply mockups of each coating system indicated to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 1. Architect will select one surface to represent surfaces and conditions for application of each coating system.
 - a. Other Items: Architect will designate items or areas required.
 2. Final approval of color selections will be based on mockups.
 - a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

- A. Apply coatings only when temperature of surfaces to be coated and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.
- C. Do not apply exterior coatings in snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 HIGH-PERFORMANCE COATINGS, GENERAL

- A. Material Compatibility:
 - 1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.
 - 3. Products shall be of same manufacturer for each coat in a coating system.
- B. VOC Content: For field applications that are inside the weatherproofing system, paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
 - 1. Flat Paints and Coatings: 50 g/L.
 - 2. Nonflat Paints and Coatings: 150 g/L.
 - 3. Primers, Sealers, and Undercoaters: 200 g/L.
 - 4. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
 - 5. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
 - 6. Pretreatment Wash Primers: 420 g/L.
 - 7. Floor Coatings: 100 g/L.
 - 8. Shellacs, Clear: 730 g/L.
 - 9. Shellacs, Pigmented: 550 g/L.
- C. Low-Emitting Materials: Interior paints and coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- D. Colors: As indicated on drawings.

2.2 SOURCE QUALITY CONTROL

- A. Testing of Coating Materials: Owner reserves the right to invoke the following procedure:
 - 1. Owner will engage the services of a qualified testing agency to sample coating materials. Contractor will be notified in advance and may be present when samples are taken. If coating materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
 - 2. Testing agency will perform tests for compliance with product requirements.
 - 3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying coating materials from Project site, pay for testing, and recoat surfaces coated with rejected materials. Contractor will be required to remove rejected materials from previously coated surfaces if, on recoating with complying materials, the two coatings are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.
- C. Proceed with coating application only after unsatisfactory conditions have been corrected.
 - 1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and coating systems indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
- C. Clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce coating systems indicated.
- D. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
1. SSPC-SP 7/NACE No. 4.
 2. SSPC-SP 11.
 3. SSPC-SP 6/NACE No. 3.
 4. SSPC-SP 10/NACE No. 2.
 5. SSPC-SP 5/NACE No. 1.
- E. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- F. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied coatings.

3.3 APPLICATION

- A. Apply high-performance coatings according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
1. Use applicators and techniques suited for coating and substrate indicated.
 2. Coat surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment or furniture with prime coat only.
 3. Coat backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 4. Do not apply coatings over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
- B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance.
- D. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and color breaks.

3.4 FIELD QUALITY CONTROL

- A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test coatings for dry film thickness.

1. Contractor shall touch up and restore coated surfaces damaged by testing.
2. If test results show that dry film thickness of applied coating does not comply with coating manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with coating manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from coating operation. Correct damage to work of other trades by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.

3.6 EXTERIOR HIGH-PERFORMANCE COATING SCHEDULE

- A. Steel Substrates:
 1. Shop Primer for Galvanized Steel: High-solids, water-based epoxy or urethane tie-coat formulated for exterior use over zinc-coated galvanized metal and compatible with finish paint systems indicated. Apply at 4 to 14 mils DFT (Dry Film Thickness) as recommended by manufacturer for specific application. Provide acceptable products and manufacturers as follows:
 - a. Series 27WB Typoxy; Tnemec Corp.
 - b. Rustbond Penetrating Sealer; Carboline
 - c. Or Approved Equal
 2. Polyamidoamine Epoxy Intermediate Coat: Compatible with primer and topcoat. Apply at 2 to 10 mils DFT (Dry Film Thickness) as recommended by manufacturer for specific application. Provide acceptable products and manufacturers as follows:
 - a. Series V69 Hi-Build Epoxoline; Tnemec Corp
 - b. Carboguard 889; Carboline
 - c. Or Approved Equal
 3. Aliphatic Acrylic Polyurethane Topcoat: Compatible with primer and intermediate coat. Apply at 2.0 to 5 mils DFT (Dry Film Thickness) as recommended by manufacturer for specific application. Provide acceptable products and manufacturers as follows:
 - a. Series 73 Endura-Shield; Tnemec Corp
 - b. Carbothane 134; Carboline
 - c. Or Approved Equal

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 099600

SECTION 10 14 00 - SIGNAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior and exterior panel signs for room identification.
3. Interior and exterior panel signs for hazard and warning notification.
4. Exterior dimensional letters and digits.
5. Accessories required for a complete installation.

B. Related Sections:

1. Division 21-27 sections for labels, tags, and nameplates for facility services equipment.
2. Section 26 51 0, "Interior Lighting", for illuminated exit signs.

1.2 SUBMITTALS

A. Make submittals in accordance with Section 01 33 00, Submittal Procedures.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Show fabrication and installation details for signs.

1. Show sign mounting heights and accessories.
2. Provide message list, typestyles, graphic elements, including tactile characters and Braille, and layout for each sign.

D. Room Numbering and Naming Schedule: For approval by OWNER.

E. Samples for Initial Selection: Manufacturer's color charts consisting of actual units or sections of units showing the full range of colors available for the following:

1. Aluminum.
2. Acrylic sheet.
3. Dimensional Characters: Full-size samples of each type of dimensional character (letter, number, and graphic element)

- F. Samples for Verification: For each of the following products and for the full range of color, texture, and sign material indicated, of sizes indicated:
 - 1. Aluminum: For each form, finish, and color, on 6-inch-long sections of extrusions and squares of sheet at least 4 by 4 inches.
 - 2. Acrylic Sheet: 8 by 10 inches for each color required.
 - 3. Panel Signs: Not less than 12 inches square including border.
 - 4. Frame: 6-inch-long sections of each profile.
 - 5. Accessories: Manufacturer's full-size unit.
- G. Qualification Data: For installer and fabricator.
- H. Maintenance Data: For signs to include in maintenance and operation manuals.
- I. Warranty: Special warranty specified in this section.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products or an employer of workers trained and recommended by manufacturer.
- B. Fabricator Qualifications: Shop that employs skilled workers who custom-fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.
- C. Source Limitations for Signs: Obtain each sign type indicated from one source from a single manufacturer.
- D. Regulatory Requirements: Comply with applicable accessibility provisions of code and ADA Standards for Accessible Design, 28 CFR Part 36, Appendix A.

1.4 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within five years from date of Final Acceptance.
 - 1. Failures include, but are not limited to, deterioration of finishes beyond normal weathering and deterioration of embedded graphic image.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Cast Acrylic Sheet: Cast (not extruded or continuous cast) methyl methacrylate monomer plastic sheet, in sizes and thicknesses indicated, with a minimum flexural strength of 16,000 psi when tested according to ASTM D790, with a minimum allowable continuous service temperature of 176 deg F:
 - 1. Transparent Sheet: Where sheet material is indicated as clear, provide colorless sheet in matte finish, with light transmittance of 92 percent, when tested according to the requirements of ASTM D1003.
 - 2. White Translucent Sheet: Where sheet material is indicated as white, provide white translucent sheet of density required to produce uniform brightness and minimum halation effects.
 - 3. Opaque Sheet: Where sheet material is indicated as opaque, provide colored opaque acrylic sheet in colors and finishes indicated.
- B. Aluminum Sheet: Provide aluminum sheet of alloy and temper recommended by the sign manufacturer for the type of use and finish indicated, and with not less than the strength and durability properties specified in ASTM B209 for 5005-H15.
- C. Aluminum Castings: Provide aluminum castings of alloy and temper recommended by the sign manufacturer for the casting process used and for the use and finish indicated.
- D. Fasteners: Recommended by manufacturer for substrate.
- E. Brackets: Fabricate brackets and fittings for bracket mounted signs from extruded aluminum to suit sign panel construction and mounting conditions indicated. Factory paint brackets in color matching background color of sign panel.
- F. Anchors and Inserts: Use nonferrous metal or hot-dipped galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or lead expansion bolt devices for drilled in place anchors. Furnish inserts, as required, to be set into concrete or masonry work.

2.2 SIGNAGE

- A. Panel Signs: Comply with requirements indicated for materials, thicknesses, finishes, colors, designs, shapes, sizes, and details of construction.
 - 1. Produce smooth, even, level sign panel surfaces, constructed to remain flat under installed conditions within a tolerance of plus or minus 1/16 inch measured diagonally.
 - 2. Graphic Content and Style: Provide sign copy complying with requirements indicated for size, style, spacing, content, position, material, finishes, and colors of letters, numbers, and other graphic devices.
 - a. For NFPA hazard signs, consult OWNER for hazard levels.

3. Copy Application: Die-cut self-adhesive vinyl or silkscreen.

2.3 FABRICATION

- A. Interior and Exterior Panel Signs for Room and Stairwell Identification: Edges mechanically and smoothly finished.
 1. Acrylic Sheet: 0.080 inch thick.
 2. Edge Condition: Beveled.
 3. Corner Condition: Square
 4. Provide signage with characters, symbols, or pictographs raised 1/32 inch and bearing appropriate braille designations.
 5. Mounting: As indicated.
 - a. Wall or door mounted with concealed anchors.
 - b. Manufacturer's standard non-corroding anchors for substrates encountered.
- C. Interior and Exterior Panel Signs for Hazard and Warning Notification:
 1. Aluminum sheet, 0.080 inch thick.
 2. Edge Condition: Tapered.
 3. Corner Condition: Square.
 4. Color: As selected by Engineer from manufacturer's full range.
 5. Finish: Baked enamel as described below.
 6. Mounting:
 - a. Wall or door mounted with noncorrosive screws and expansion shields.
 - b. Bracket mounted, 2 by 2-1/2 by 3/16 inch angle.
 - c. Fence mounted using neoprene spacers, with same sized back panel on opposite side of fence material.
 - d. Suspended from chain with rings.
- D. Dimensional (Cutout) Letters and Numbers: Cut letters and numbers from solid plate material of thickness indicated. Produce precisely cut characters with square cut, smooth edges. Comply with requirements indicated for finish, style, and size.

1. Cast Characters: Produce characters with smooth flat faces, sharp corners, and precisely formed lines and profiles, free of pits, scale, sand holes, and other defects. Cast lugs into back of characters and tap to receive threaded mounting studs. Alloy and temper recommended by sign manufacturer for casting process used and for use and finish indicated. Comply with the following requirements.
 - a. Character Material: Aluminum.
 - b. Thickness: 1 inch.
 - c. Color: As selected by Engineer from manufacturer's full range.
 - d. Finish: Anodized as described below.
 - e. Mounting: Concealed studs, noncorroding for substrates encountered.

2.4 FINISHES

- A. Colors and Surface Textures: For exposed sign material that requires selection of materials with integral or applied colors, surface textures or other characteristics related to appearance, provide color matches indicated, or if not indicated, as selected by Engineer from manufacturer's standards.
- B. Metal Finishes: Comply with NAAMM Metal Finishes Manual for Architectural and Metal Products for finish designations and applications recommendations.
- C. Aluminum Finishes: Finish designations prefixed by "AA" conform to the system established by the Aluminum Association for designating aluminum finishes.
 1. Class II Clear Anodized Fine Satin Finish: AA-M31C21A31 (Mechanical Finish: Fine satin directional textured; Chemical Finish: Fine matte etched finish; Anodic Coating: Class II Architectural, clear film thicker than 0.4 mil).
 2. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Apply baked enamel complying with paint manufacturer's written instructions for cleaning, conversion coating, and painting.
 - a. Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 1.5 mils, medium gloss.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units plumb and level, in locations and with mountings shown. Securely attach in accordance with the manufacturer's installation instructions.
- B. Plastic Wall and Door Mounted Signs: Attach panel signs to wall and door surfaces in accordance with requirements above.
 - 1. Silicone Adhesive Mounting: Use liquid silicone adhesive recommended by the sign manufacturer to attach sign units to irregular, porous, or vinyl covered surfaces. Use double sided vinyl tape where recommended by the sign manufacturer to hold the sign in place until the adhesive has fully cured.
- C. Dimensional Letters and Numbers: Mount letters and numbers using standard fastening methods recommended by the manufacturer for letter form, type of mounting, wall construction, and condition of exposure indicated. Provide heavy paper template to establish letter spacing and to locate holes for fasteners.

3.2 CLEANING AND PROTECTION

- A. At completion of installation, clean soiled sign surfaces in accordance with manufacturer's instructions. Protect units from damage until acceptance by OWNER.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. No separate measurement will be made for the work of this section.

4.2 PAYMENT

- A. Payment for the work of this section will be included in lump sum payment(s) for the applicable building or facility in accordance with the Schedule of Values.

END OF SECTION 10 14 00

SECTION 10 82 13.1 - MECHANICAL EQUIPMENT SCREENS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pre-formed painted metal panel for enclosing roof top mechanical equipment.
 - 2. Aluminum assembly framing for indirect attachment of screening panels to mechanical equipment curb or roof assembly.
 - 3. Sliding panels to permit easy access to mechanical equipment for servicing.
- B. Products Not Installed or Furnished in This Section:
 - 1. Touch-up painting required for scratches and screw heads.
 - 2. Field painting of prime painted screens

1.2 REFERENCES

- A. American Society for Testing and Materials: Standard Specifications for
 - 1. ASTM B 221-96 - Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire Profiles, and Tubes.
- B. The Aluminum Association, Inc.
 - 1. AA ADM-1516166 (1994) - Aluminum Design Manual
- C. American Society of Civil Engineers.
 - 1. ASCE 7-95 - Minimum Design Loads for Buildings and Other Structures.

1.3 SYSTEM DESCRIPTION

- A. Design Criteria:
 - 1. Manufacturer is responsible for the structural design of all materials, assembly and attachments to resist snow, wind, suction and uplift loading at any point without damage or permanent set.
 - 2. Framing shall be designed in accordance with the Aluminum Design Manual to resist the following loading:
 - a. ASCE 7-95 - Minimum Design Loads for Buildings and Other Structures; American Society of Civil Engineers.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's catalog data, detail sheets, specification and other data sufficient to indicate compliance with these specifications.
- B. Shop Drawings: Indicate layouts heights, component connection details, and details of interface with adjacent construction. Mark data to indicate:
 - 1. Roof top mechanical equipment to be enclosed.
- C. Samples:
 - 1. Samples of Materials: painted metal

Color Selection: Submit paint chart with full range of colors available for Architect's selection. Match finish of manufactured wall panels for an uninterrupted appearance. Closeout Submittals: Warranty documents, issued and executed by manufacturer, countersigned by Contractor.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with requirements of building authorities having jurisdiction in Project location.
- B. Manufacturer Qualifications: Minimum five (5) years documented experience producing systems specified in this section.
- C. Pre-Installation Meeting:
 - 1. Convene at job site seven (7) calendar days prior to scheduled beginning of construction activities of this section to review requirements of this section.
 - 2. Require attendance by representatives of the installing subcontractor, (who will represent the system manufacturer) and other entities directly affected by construction activities of this section.
 - 3. Notify Architect four (4) calendar days in advance of scheduled meeting date.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.
- B. Storage and Handling: Protect materials and finishes during handling and installation to prevent damage.

1.7 PROJECT CONDITIONS

- A. Field Measurements: Take measurements of actual roof top unit for fit without gaps. Indicate measurements on shop drawings fully documenting any field condition that may interfere with the screen system installation.

1.8 COORDINATION

- A. Installer for work under this Section shall be responsible for coordination of panel and framing sizes and required options with the Contractor's requirements.
 - 1. Request information on sizes and options required from the Contractor.
- B. Submit shop drawings to the Contractor and obtain written approval of shop drawing from the Contractor prior to fabrication.

1.9 WARRANTY

- A. If any part of the rooftop equipment screen fails because of a manufacturing defect within one year from the date of substantial completion, the manufacturer will furnish without charge the required replacement part(s). Any local transportation, related service labor or diagnostic call charges are not included.
- B. This warranty does not cover failure of your rooftop equipment screen if it is damaged by the Owner, or if the failure is caused by improper installation. In no event shall Warrantor be liable for incidental or consequential damages.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Products: Envisor Screening System by CityScapes Incorporated, 4200 Lyman Ct. Hilliard, OH 43026. 1-877-727-3367 www.cityscapesinc.com
- B. Substitutions: or equal

2.2 MATERIALS

- A. Painted Metal Panels: Fabricated from rigid aluminum panels in multiple thicknesses.
 - 1. Minimum thickness: 0.063
- B. Perforated Metal Panels: Fabricated from rigid [aluminum] [steel] panels in multiple thicknesses.
 - 1. Minimum thickness: 0.063
- C. Framing: Aluminum Plate, Shapes and Bar: ASTM B 221, alloy 6061-T5 or 6063-T5.
- D. Threaded Fasteners: All screws, bolts, nut and washers shall be Stainless steel.
 - 1. Corner assembly fasteners shall be #10-16 x stainless steel TEK screws. Length as required to develop full holding capacity of screw when fastened to Mechanical Equipment.
 - 2. Provide lock washer or other locking device at all bolted connections.

2.3 FABRICATION

- A. Provide factory-formed panel systems with continuous interlocking panel connections and indicated or necessary components: Form all components true to shape, accurate in size, square and free from distortion or defects. Cut panels to precise lengths indicated on approved shop drawings.
- B. Fabricate all panels to slide horizontally to allow access to unit access panels behind.
- C. Panel Design, Style, Trim:
 - 1. Panel Style: Metal
 - 2. Panel Design: Ribbed
 - 3. Decorative Top Trim Profile: Band
- D. Trim and Closures: Fabricated from 24 gage metal, and finished with the manufacturers standard coating system, unless shown otherwise on drawings.
- E. Framing: Fabricate and assemble components in largest practical sizes, for delivery to the site.
 - 4. Construct corner assemblies to required shape with joints tightly fitted.
 - 5. Supply components required for anchorage of framing. Fabricate anchors and related components of material and finish as required, or as specifically noted.

2.4 FINISHES

- A. Aluminum Framing: Mill finish.
- B. Panel Coating: Manufacturer's standard coating system, factory-applied.
 - 1. Color: Selected from full range of manufacturer's standard colors.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Installer's Examination: Examine conditions under which construction activities of this section are to be performed.
 - 1. Submit written notification to Architect and Screen manufacturer if such conditions are

unacceptable.

2. Beginning erection constitutes installer's acceptance of conditions.

3.2 INSTALLATION

- A. Install units in accordance with the manufacturer's instructions and approved shop drawings. Keep perimeter lines straight, plumb, and level. Provide brackets, anchors, and accessories necessary for a complete installation.
- B. Fasten structural supports to HVAC units without damaging operation of the unit.
 1. Provide corner and mid-span assemblies as required by approved shop drawings so that the panels are supported uniformly.
 2. Fastening bottom rail using bolts to permit ease of access to HVAC units.
- C. Metal Separation: Where aluminum materials would contact dissimilar materials, insert rubber grommets at attachment points, thus eliminating where dissimilar metals would otherwise be in contact.
- D. Do not cut or abrade finishes which cannot be restored. Return items with such finishes to shop for required alterations.

3.3 ERECTION TOLERANCES

- A. Maximum misalignment from true position: $\frac{1}{4}$ inch (6 mm).

3.4 CLEANING AND PROTECTION

- A. Remove all protective masking from material immediately after installation.
- B. Protection:
 1. Ensure that finishes and structure of installed systems are not damaged by subsequent construction activities.
 2. If minor damage to finishes occurs, repair damage in accordance with manufacturer's recommendations; provide replacement components if repaired finishes are unacceptable to Architect.
- C. Prior to Substantial Completion: Remove dust or other foreign matter from component surfaces; clean finishes in accordance with manufacturer's instructions.
- D. Clean units in accordance with the manufacturer's instructions.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 108213

SECTION 11 81 29 - FACILITY FALL PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes fall-protection equipment including:
 - 1. Weldable Rooftop Axis anchors.
- B. Related Requirements:
 - 1. Section 055000 "Metal Fabrications" for miscellaneous metal fabrications.
 - 2. Section 076200 "Sheet Metal Flashing and Trim" for flashing and trim components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include manufacturer's data and product information indicating descriptions, material, dimensions, capacities, and test certifications for fall-protection equipment.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies.
 - 3. Include layout drawings for each system in relation to the supporting structure. Indicate locations of components.
- C. Product Schedule: For fall-protection equipment.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
 - 1. Provide certified proof of Installer's approval by manufacturer.

- B. Welding certificates.
- C. Product Certificates: For each type of fall-protection equipment indicating manufacturer's batch number on each individual component used in systems specified.
- D. Material Test Reports: For each component, by a qualified testing agency.
- E. Product Test Reports: For each system, for tests performed by a qualified testing agency.
- F. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fall-protection equipment to include the following:
 - 1. Parts lists and maintenance requirements.
 - 2. Manufacturer's catalog data indicating sizes, descriptions, capacities, and test certifications.
- B. Record Documentation: Include Record Drawings in the operation and maintenance manual.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: OSHA approved.
- B. Installer Qualifications: An entity that employs installers and supervisors who are authorized, trained, and certified by manufacturer.
- C. Engineer for Delegated-Design Qualifications: Structural engineer licensed in the jurisdiction and experienced in engineering fall-protection systems.
- D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in manufacturer's original unopened packaging.
- B. Store materials in original protective packaging.
- C. Protect from soiling, moisture, and physical damage.

1.8 FIELD CONDITIONS

- A. Coordinate layout and installation of framing and reinforcements for fall-protection equipment.
- B. Maintain environmental conditions within limits recommended by manufacturer. Do not install products under environmental conditions outside manufacturer's recommended limits.

1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace fall-protection equipment that fail(s) in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 20 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain each type of fall-protection equipment from single source from single manufacturer.

2.2 DESCRIPTION

- A. Regulatory Requirements: Products to meet or exceed OSHA and ASME A 120.1, as tested and certified by professional engineer.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design fall-protection systems.
- B. Capacities and Characteristics:
 - 1. Capable of sustaining a maximum fall-arresting force of 1800 lbf when wearing a body harness with a factor of two without any permanent deformation and to 5000 lbf against fracture or detachment.

2.4 AXIS ANCHOR DEVICES

A. Stanchion Anchors:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Rooftop Anchor, Inc.: Roof axis anchor or comparable product by one of the following:
 - a. Guardian.
2. Attachment Method: Weldable or Bolt through.
3. Rooftop Anchor Height: 15 inches.
4. Working Load: 1250 lb.
5. Ultimate Load: 5000 lb.
6. Reinforcement: Steel beam reinforcement as required.

2.5 FABRICATION

- A. Shop Assembly: Per OSHA requirements.
- B. Tolerances: Per OSHA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Coordinate location of fall-protection equipment indicated to be attached to structural substrate or surface of roofing system, and furnish anchoring devices with templates and diagrams.

3.3 INSTALLATION

- A. Install according to approved Shop Drawings and manufacturer's instructions. Coordinate with work of other trades.

- B. Install anchorage and fasteners in accordance with manufacturer's recommendations to obtain the allowable working loads published in the product literature and in accordance with this specification.
- C. Exposed work shall be true to line and level with accurate angles, surfaces, and with straight square edges. Coordinate anchorage system with supporting structure.
- D. Do not load or stress system until materials and fasteners are properly installed and ready for service.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-certified installer to inspect components, assemblies, and equipment installations, including connections.
- B. Ensure that system components operate as specified.

3.5 ADJUSTING

- A. Adjust fall-protection components to function smoothly and safely.

3.6 CLEANING

- A. Clean components of any deleterious coatings or compounds. Remove loose materials, crating, and packing materials from Project site.

3.7 MAINTENANCE

- A. OSHA and ANSI/TWCA I 14.1 require that anchors first be certified and subsequently inspected on an annual basis. Coordinate with the manufacturer and local inspectors as required to maintain compliance.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 11 81 29

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SECTION 14 24 00 - HYDRAULIC ELEVATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes hydraulic passenger elevators.
- B. Related Requirements:
 - 1. Section 015000 "Temporary Facilities and Controls" for temporary use of elevators for construction purposes.
 - 2. Section 033000 "Cast-in-Place Concrete" for setting sleeves, inserts, and anchoring devices in concrete.
 - 3. Section 042000 "Concrete Unit Masonry" for setting sleeves, inserts, and anchoring devices in masonry and for grouting elevator entrance frames installed in masonry walls.
 - 4. Section 051200 "Structural Steel Framing" for the following:
 - a. Attachment plates, angle brackets, and other structural-steel preparations for fastening guide-rail brackets.
 - b. Hoist beams.
 - c. Structural-steel shapes for subsills that are part of steel frame.
 - 5. Section 055000 "Metal Fabrications" for the following:
 - a. Attachment plates and angle brackets for supporting guide-rail brackets.
 - b. Hoist beams.
 - c. Structural-steel shapes for subsills.
 - d. Pit ladders.
 - e. Cants made from steel sheet in hoistways.
 - 6. Section 221429 "Sump Pumps" for sump pumps, sumps, and sump covers in elevator pits.
 - 7. Section 283111 "Fire Alarm Systems" to initiate emergency operation and for connection to elevator controllers.

1.3 DEFINITIONS

- A. Definitions in ASME A17.1/CSA B44 apply to work of this Section.
- B. Service Elevator: A passenger elevator that is also used to carry freight.

1.4 ACTION SUBMITTALS

- A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for car enclosures; hoistway entrances; and operation, control, and signal systems.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and large-scale details indicating service at each landing; machine room layout; coordination with building structure; relationships with other construction; and locations of equipment.
 - 2. Include large-scale layout of car-control station and standby-power operation control panel.
 - 3. Indicate maximum dynamic and static loads imposed on building structure at points of support as well as maximum and average power demands.
- C. Samples for Initial Selection: For finishes involving color selection.
- D. Samples for Verification: For exposed car, hoistway door and frame, and signal equipment finishes, 3-inch-square Samples of sheet materials and 4-inch lengths of running trim members.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Manufacturer Certificates: Signed by elevator manufacturer, certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service including standby-power generator, as shown and specified, are adequate for elevator system being provided.
- C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
 - 1. Submit manufacturer's/installer's standard operation and maintenance manual, in accordance with ASME A17.1/CSA B44 including diagnostic and repair information available to manufacturer's and Installer's maintenance personnel.
- B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.
- C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard two-year maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Elevator manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle materials, components and equipment in manufacturer's protective packaging. Store materials, components, and equipment off of ground, under cover, and in a dry location.

1.9 COORDINATION

- A. Coordinate installation of sleeves, block outs, elevator equipment with integral anchors, and other items that are embedded in concrete or masonry for elevator equipment. Furnish templates, sleeves, elevator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.
- B. Coordinate locations and dimensions of other work specified in other Sections that relates to hydraulic elevators, including pit ladders; sumps and floor drains in pits; entrance subsills; electrical service; and electrical outlets, lights, and switches in hoistways, pits, and machine rooms.

1.10 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
 - 2. Warranty Period: two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 HYDRAULIC ELEVATOR MANUFACTURERS

- A. The basis of design is the Endura, Twinpost above-ground as manufactured by ThyssenKrupp Elevator or an approved equal.
- B. Source Limitations: Obtain elevators from single manufacturer.
 - 1. Major elevator components, including pump-and-tank units, plunger-cylinder assemblies, controllers, signal fixtures, door operators, car frames, cars, and entrances, shall be manufactured by single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.
- B. Accessibility Requirements: Comply with Section 407 in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

2.3 ELEVATORS

- A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturers' standard components shall be used, as included in standard elevator systems and as required for complete system.
- B. Elevator Description:
 - 1. Group Number: One.
 - 2. Elevator Number(s): Three.
 - 3. Emergency Elevator Number(s): One.
 - 4. Type: Holeless, beside-the-car, telescoping, dual cylinders.
 - 5. Rated Load: 4500 lb.
 - 6. Freight Loading Class for Service Elevators: Class A.
 - 7. Rated Speed: 150 fpm.
 - 8. Operation System: Single automatic operation.
 - 9. Auxiliary Operations:
 - a. Standby-power operation.
 - b. Standby-powered lowering.
 - c. Automatic operation of lights and ventilation fans.
 - 10. Security Features: Key switch operation.
 - 11. Car Enclosures:
 - a. Inside Width: not less than 68 inches from side wall to side wall.
 - b. Inside Depth: Not less than 93-1/2 inches from back wall to front wall (return panels).
 - c. Inside Height: Not less than 88 inches to underside of ceiling.
 - d. Front Walls (Return Panels): Satin stainless steel, No. 4 finish with integral car door frames.
 - e. Car Fixtures: Satin stainless steel, No. 4 finish.
 - f. Side Wall Panels: Embossed pattern 5WL. Rear Wall Panel: Stainless steel. Satin stainless steel, No. 4 finish
 - g. Reveals: Black.
 - h. Braille: Surface mount cast Braille plate with raised floor elevator identification.
 - i. Door Faces (Interior): Satin stainless steel, No. 4 finish.
 - j. Door Sills: Nickle silver
 - k. Ceiling: Panels with Satin stainless steel, No. 4 finish. and LED lighting
 - l. Handrails: flat bar 1/4" thick x 6" wide, mirror-polished stainless steel, No. 8 finish, at sides and rear of car.
 - m. Floor: single sheet of 6061-T6 Aluminum Diamond Plate (Min. 3/16" Thick) installed with stainless steel recessed hex head bolts.

12. Cab Dimensions:
 - a. Width: 5' - 8" maximum width
 - b. Depth: 7' - 9 1/2" maximum depth
13. Hoistway Entrances and Features:
 - a. Door Width: 48 inches.
 - b. Door Height: 84 inches.
 - c. Type: Two-speed side sliding.
 - d. Frames: Satin stainless steel, No. 4 finish.
 - e. Doors: Satin stainless steel, No. 4 finish.
 - f. Sills at First Floor: Nickel silver
 - g. Sills at Other Floors: Nickel silver
 - h. Hoistway Pit Depth: 5'-0"
 - i. ADA Compliant
 - j. Elevator to accommodate a 24x84 ambulance stretcher per current code.
14. Hall Fixtures: combination LED hall lantern and position indicator, vandal resistant with directional arrow Satin stainless steel, No. 4 finish at each floor
15. Additional Requirements:
 - a. Provide inspection certificate in each car, mounted under acrylic cover with frame made from satin stainless steel, No. 4 finish.

2.4 SYSTEMS AND COMPONENTS

- A. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations.
 1. Pump shall be submersible type with submersible squirrel-cage induction motor, and shall be suspended inside oil tank from vibration isolation mounts.
 2. Motor shall have variable-voltage, variable-frequency control.
- B. Hydraulic Silencers: System shall have hydraulic silencer containing pulsation-absorbing material in blowout-proof housing at pump unit.
- C. Piping: Size, type, and weight of piping as recommended by elevator manufacturer, with flexible connectors to minimize sound and vibration transmissions from power unit.
- D. Hydraulic Fluid: Nontoxic, biodegradable, fire-resistant fluid, made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives, that is approved by elevator manufacturer for use with elevator equipment.
- E. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work. Device installation is specified in another Section.
- F. Car Frame and Platform: Welded or bolted steel units.

- G. Guides: Roller guides. Provide guides at top and bottom of car frame.

2.5 OPERATION SYSTEMS

- A. General: Provide manufacturer's standard microprocessor operation system as required to provide type of operation indicated.
- B. Auxiliary Operations:
1. Single-Car Standby-Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at fire command station. Manual operation causes automatic operation to cease.
 2. Single-Car Standby-Powered Lowering: On activation of standby power, if car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to a preselected floor, opens its doors, and shuts down. If car is below the preselected floor, it is lowered to the next lower floor, opens its doors, and shuts down.
 3. Single-Car Standby-Powered Lowering: On activation of standby power, car is lowered to the lowest floor, opens its doors, and shuts down.
 4. Group Standby-Power Operation: On activation of standby power, cars are returned to a designated floor and parked with doors open. Only one car is moved upward at a time, with priority given to loaded cars. If a car cannot be returned after two attempts, it is removed from the system. When all cars have been returned or removed from the system, one car is automatically placed in service. If car selected for service cannot operate within 60 seconds, the system removes car from service and places another car in service. Cars can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at fire command station. Manual operation causes automatic operation to cease.
 5. Group Standby-Powered Lowering: On activation of standby power, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are lowered to a preselected floor, open their doors, and shut down. Cars that are below the preselected floor are lowered to the next lower floor, open their doors, and shut down.
 6. Group Standby-Powered Lowering: On activation of standby power, cars are lowered to the lowest floor, open their doors, and shut down.
 7. Independent Service: Key switch in car-control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from key switch when car is in independent service. When in independent service, doors close only in response to door close button.
 8. Automatic Operation of Lights and Fan: When elevator is stopped and unoccupied with doors closed, lighting, ventilation fan, and cab displays are de-energized after 5 minutes and are re-energized before car doors open.
- C. Security Features: Security features shall not affect emergency firefighters' service.
1. Key switch Operation: Push buttons are activated and deactivated by security key switches at car-control stations. Key is removable in either position.

2.6 DOOR-REOPENING DEVICES

- A. Infrared Array: Provide door-reopening device with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.
- B. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door-reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

2.7 CAR ENCLOSURES

- A. General: Provide enameled- or powder-coated-steel car enclosures to receive removable wall panels, with removable car roof, access doors, power door operators, and ventilation.
 - 1. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.
- B. Materials and Finishes: Manufacturer's standards, but not less than the following:
 - 1. Subfloor: Exterior, C-C Plugged grade plywood, not less than 7/8-inch nominal thickness.
 - 2. Floor Finish: 6061-T6 Aluminum Diamond Plate (Min. 3/16" Thick).
 - 3. Stainless-Steel Wall Panels: Flush, formed-metal construction; fabricated from stainless-steel sheet.
 - 4. Fabricate car with recesses and cutouts for signal equipment.
 - 5. Fabricate car door frame integrally with front wall of car.
 - 6. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
 - 7. Sight Guards: Provide sight guards on car doors.
 - 8. Sills: Extruded or machined metal, with grooved surface, 1/4 inch thick.
 - 9. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
 - 10. Metal Ceiling: Flush panels, with LED downlight in each panel. Align ceiling panel joints with joints between wall panels.
 - 11. Light Fixture Efficiency: Not less than 35 lumens/W.
 - 12. Ventilation Fan Efficiency: Not less than 3.0 cfm/W.

2.8 HOISTWAY ENTRANCES

- A. Hoistway Entrance Assemblies: Manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Frame size and profile shall accommodate hoistway wall construction.
 - 1. Where gypsum board wall construction is indicated, frames shall be self-supporting with reinforced head sections.
- B. Fire-Rated Hoistway Entrance Assemblies: Door-and-frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities

having jurisdiction based on testing at as close-to-neutral pressure as possible according to NFPA 252.

1. Fire-Protection Rating: 1 hour with 30-minute temperature rise of 450 deg F.

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:

1. Enameled- or Powder-Coated-Steel Frames: Formed from cold- or hot-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Primed or Powder-Coated-Steel Frames: Formed from cold- or hot-rolled steel sheet. Provide with factory-applied, rust-resistant primer or powder coating for field painting.
3. Stainless-Steel Frames: Formed from stainless-steel sheet.
4. Star of Life Symbol: Identify emergency elevators with star of life symbol, not less than 3 inches high, on both jambs of hoistway door frames.
5. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
6. Sight Guards: Provide sight guards on doors matching door edges.
7. Sills: Extruded or machined metal, with grooved surface, 1/4 inch thick.
8. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M.

2.9 SIGNAL EQUIPMENT

- A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Provide vandal-resistant buttons and lighted elements illuminated with LEDs.
- B. Car-Control Stations: Provide manufacturer's standard recessed car-control stations. Mount in return panel adjacent to car door unless otherwise indicated.
 1. Mark buttons and switches for required use or function. Use both tactile symbols and Braille.
 2. Provide "No Smoking" sign matching car-control station, either integral with car-control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.
- C. Emergency Communication System: Two-way voice communication system, with visible signal, which dials preprogrammed number of monitoring station and does not require handset use. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
- D. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Section 260519 "Low Voltage Power Conductors and Cable".
- E. Car Position Indicator: Provide illuminated, vandal resistant type car position indicator, located above car door or above car-control station. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

- F. Hall Push-Button Stations: Provide one hall push-button station at each landing.
1. Provide units with flat faceplate for mounting with body of unit recessed in wall.
 2. Equip vandal resistant units with buttons for calling elevator and for indicating applicable direction of travel.
 3. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Section 260519 "Low Voltage Power Conductors and Cables".
- G. Hall Lanterns: Units with illuminated arrows; however, provide single arrow at terminal landings. Provide the following:
1. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
- H. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
1. At manufacturer's option, audible signals may be placed on cars.
- I. Hall Position Indicators: Provide illuminated, digital-display-type position indicators, located above each hoistway entrance.
1. Provide units with flat faceplate for mounting and with body of unit recessed in wall.
 2. Integrate ground-floor hall lanterns with hall position indicators.
- J. Standby-Power Elevator Selector Switches: Provide switches, as required by ASME A17.1/CSA B44, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open.
- K. Fire-Command-Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby-power elevator selector switch(es), as required by ASME A17.1/CSA B44, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.
- L. Emergency Pictorial Signs: Fabricate from materials matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire, elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station unless otherwise indicated.

2.10 FINISH MATERIALS

- A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, commercial steel, Type B, exposed, matte finish.
- B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, commercial steel, Type B, pickled.
- C. Stainless-Steel Sheet: ASTM A240/A240M, Type 304.

- D. Textured Stainless-Steel Sheet: ASTM A240/A240M, Type 304, with embossed texture rolled into exposed surface (5WL).
- E. Stainless-Steel Bars: ASTM A276, Type 304.
- F. Stainless-Steel Tubing: ASTM A554, Grade MT 304.
- G. Aluminum Extrusions: ASTM B221, Alloy 6063.
- H. Nickel Silver Extrusions: ASTM B151/B151M, Alloy UNS No. C74500 or No. C77600.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Verify critical dimensions and examine supporting structure and other conditions under which elevator work is to be installed.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.
- B. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.
- C. Install piping above the floor, where possible. Install underground piping in casing.
 - 1. Excavate for piping and backfill encased piping according to applicable requirements in Section 312000 "Earth Moving."
- D. Lubricate operating parts of systems as recommended by manufacturers.
- E. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay installation of sills and frames until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.
- F. Leveling Tolerance: 1/4 inch, up or down, regardless of load and travel direction.

- G. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nontrunk, nonmetallic grout.
- H. Locate hall signal equipment for elevators as follows unless otherwise indicated:
 - 1. Place hall lanterns either above or beside each hoistway entrance.

3.3 FIELD QUALITY CONTROL

- A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.
- B. Advise Owner, Architect, and authorities having jurisdiction in advance of dates and times that tests are to be performed on elevators.

3.4 PROTECTION

- A. Temporary Use: Limit temporary use for construction purposes to one elevator. Comply with the following requirements for elevator used for construction purposes:
 - 1. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
 - 2. Provide strippable protective film on entrance and car doors and frames.
 - 3. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.
 - 4. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
 - 5. Do not load elevators beyond their rated weight capacity.
 - 6. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleanup, and adjustment as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
 - 7. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate elevator(s).
- B. Check operation of each elevator with Owner's personnel present before date of Substantial Completion and again not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

3.6 MAINTENANCE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
1. Perform maintenance during normal working hours.
 2. Submit parts catalog and show evidence of local parts inventory with a complete list of recommended spare parts. Parts must be produced by manufacturer of original equipment.
 3. Manufacturer shall have a service office and full time service personnel within 100 miles radius of the project site.
 4. Perform emergency callback service during normal working hours with response time of two hours or less.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 14 24 00

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, with plain ends and integral welded waterstop collar.
- B. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20 psig minimum.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Carbon steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 GROUT

- A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
- B. Install sleeves in concrete floors and concrete walls as new slabs and walls are constructed.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves.
 - 2. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 220517

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valve
2. Valve box

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B16.18 for solder-joint connections.
4. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:

1. Description:
 - a. Standard: MSS SP-110 or MSS-145.
 - b. CWP Rating: 600 psig.
 - c. Body Design: Two piece.
 - d. Body Material: Bronze.
 - e. Ends: Threaded and soldered.
 - f. Seats: PTFE.
 - g. Stem: Bronze or brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Full.
 - j. Stem: Bronze or brass.
 - k. Ball: Chrome-plated brass.
 - l. Port: Full.
 - m. O-Ring Seal: EPDM or Buna-N.

2.3 VALVE BOXES

- A. Cast iron extension type with slide adjustment and flared base, with the word "WATER" cast in the cover. The boxes shall be such length as will be adapted without full extension, to the depth of cover required over the pipe at the valve location.
- B. All valves which are directly buried shall be provided with a valve box and the valve coated with a coal-tar enamel coating or encased in polyethylene.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.

- D. Install valves in position to allow full stem movement.

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

3.3 DOMESTIC COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
 - 1. Bronze ball valves, two-piece with full port and bronze or brass trim. Provide with threaded or solder joint ends.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 220523.12

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Fastener systems.
3. Pipe-positioning systems.
4. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings. Show fabrication and installation details and include calculations.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized.

2.3 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
1. Outdoor Applications: Stainless steel.

2.4 MATERIALS

- A. Structural Steel: ASTM A 36/A 36M carbon-steel plates, shapes, and bars; black and galvanized.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- D. Install hangers and supports to allow controlled thermal and movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- E. Install lateral bracing with pipe hangers and supports to prevent swaying.
- F. Install building attachments attach to structural steel. Install additional attachments at concentrated loads and at changes in direction of piping.
- G. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.3 METAL FABRICATIONS

- A. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- B. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods.

3.5 PAINTING

- A. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping that will not have field-applied finishes.
- D. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated, stationary pipes.
- E. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers if longer ends are required for riser clamps.
- F. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13):
 - 2. Steel Clevises (MSS Type 14):
 - 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
 - 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - 5. Steel Weldless Eye Nuts (MSS Type 17): piping installations.
- G. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe labels

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 2. Lettering Size: Size letters according to ASME A13.1 for piping.

PART 3 - EXECUTION

3.1 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.2 PIPE LABEL INSTALLATION

- A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Pipe Label Color Schedule:

1. Domestic Water Piping
 - a. Background: Safety green.
 - b. Letter Colors: White.
2. Storm Drainage Piping:
 - a. Background Color: Safety gray.
 - b. Letter Color: White.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 220553

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Piping joining materials.
3. Dielectric fittings.

1.2 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.

1.3 INFORMATIONAL SUBMITTALS

- A. System purging and disinfecting activities report.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14 and NSF 61.

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
- B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

2.3 PIPING JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys.
- B. Flux: ASTM B 813, water flushable.

2.4 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under slab according to CDA's "Copper Tube Handbook."
- C. Install shutoff valve at domestic water-service entrance. Comply with requirements for drain valves in Section 221119 "Domestic Water Piping Specialties."
- D. Install domestic water piping slope downward toward drain and plumb.
- E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- F. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- G. Install piping to permit valve servicing.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install sleeves for piping penetrations of walls. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

- K. Install sleeve seals for piping penetrations of concrete slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

3.2 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- D. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.

3.3 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

3.4 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

- c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- 2. Piping Tests:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Perform the following adjustments before operation:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to fully open position.
 - 3. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 - 4. Close drain valves and replace drain plugs.

3.7 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

- a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.
- B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.8 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller shall be of the following:
- 1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings.
- C. Aboveground domestic water piping, NPS 2 and smaller shall be of the following:
- 1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Hose bibbs.
 - 2. Ground hydrants.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For domestic water piping specialties.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water Piping and components shall comply with NSF 61
- B. Comply with NSF 372 for low lead.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 HOSE BIBBS

- A. Hose Bibbs :

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish: Chrome plated.
9. Operations: Operating key.
10. Include operating key with each operating-key hose bibb.

2.4 GROUND HYDRANTS

- A. Nonfreeze Ground Hydrants; Zurn model Z1360-VB or approved equal.

1. Standard: ASME A112.21.3M for concealed outlet, self-draining ground hydrants.
2. Operation: Loose key.
3. Galvanized steel casing, bronze interior parts and non-turning operating rod.
4. Inlet: NPS 3/4.
5. Outlet: Concealed, with adapter vacuum breaker and garden-hose thread complying with ASME B1.20.7.
6. Box: Flush mounted with concrete slab.
7. Box and Cover Finish: Bronze box and scoriated cover.
8. Tapped 1/4" drain port in valve housing.

PART 3 - EXECUTION

3.1 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

3.2 FIELD QUALITY CONTROL

- A. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- B. Prepare test and inspection reports.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 221119

SECTION 221413 – STORM DRAINAGE PIPING AND ROOF DRAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pipe, tube, and fittings.
 - 2. Specialty pipe fittings.
 - 3. Roof drains.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 GALVANIZED-STEEL PIPE AND FITTINGS

- A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight. Include square-cut-grooved or threaded ends matching joining method.
- B. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12 threaded.
- C. Galvanized-Steel-Pipe Appurtenances:
 - 1. Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 536 ductile-iron castings, ASTM A 47/A 47M malleable-iron castings, ASTM A 234/A 234M

- forged-steel fittings, or ASTM A 106/A 106M steel pipes with dimensions matching ASTM A 53/A 53M steel pipe, and complying with AWWA C606 for grooved ends.
2. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.

2.3 METAL ROOF DRAINS

A. Cast-Iron, Small-Sump, General-Purpose Roof Drains (RD & RD-S):

1. Standard: ASME A112.6.4, for general-purpose roof drains.
2. Body Material: Cast iron.
3. Combination Flashing Ring and Gravel Stop: Required.
4. Outlet: Bottom.
5. Underdeck Clamp: Required.
6. Dome Material: Cast iron.
7. Overflow Drain (RD-S): Extend pipe 3 inch or above flood elevation.

2.4 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft.
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- D. Fasteners: Metal compatible with material and substrate being fastened.
- E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- F. Solder: ASTM B 32, lead-free alloy.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Unshielded, Nonpressure Transition Couplings:
 - a. Standard: ASTM C 1173.

- b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
- c. Sleeve Materials:
 - 1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- 4. Shielded, Nonpressure Transition Couplings:
 - a. Standard: ASTM C 1460.
 - b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 - 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 - 2. Position roof drains for easy access and maintenance.
- B. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to NPS 4.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller.
 - 4. Locate cleanouts at base of each vertical soil and waste stack.

3.2 FLASHING INSTALLATION

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
 - 2. Copper Sheets: Solder joints of copper sheets.
- B. Set flashing on roofs in solid coating of bituminous cement.
- C. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.4 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping indicated to be exposed at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- C. Install piping free of sags and bends.
- D. Install fittings for changes in direction and branch connections.
- E. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- F. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - 1. Horizontal Storm-Drainage Piping: 1 percent downward in direction of flow.
- G. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- H. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
 - 3. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - 4. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 5. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

- 6. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
- E. Install supports for vertical piping every 15 feet.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and storm drainage specialties.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.7 IDENTIFICATION

- A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.9 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 221413

SECTION 22 14 23.10 – PLATFORM CHANNEL DRAINAGE SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Platform Trench drainage

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, shop drawings showing system layout, cross sections, including expansion joint/ control joint details, and grating.

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, and grate tested to AASHTO M-306.

PART 2 - PRODUCTS

2.1 TRENCH DRAIN SYSTEMS

- A. Narrow, Sloped-Invert, Polyester Polymer Concrete, Channel Drainage Systems as shown on Architectural drawings:
 - 1. Basis of design: PolyDrain, Trench Drain System as manufactured by ABT, Inc., 259 Murdock Road, Troutman, NC (800) 438-6057 or approved equal.
 - 2. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
 - a. Channel Sections: Narrow, interlocking-joint, sloped-invert, polymer-concrete modular units with end caps.
 - 1) Include rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated.
 - 2) Include extension sections necessary for required depth.
 - 3) Dimensions: Nominal 6-inch outside width, 4-inch inside width and inside depth varies. Include number of units required to form total lengths indicated. Interlocking tongue and groove joints

- 4) Frame: Galvanized cast iron frames.
- b. Grates: Manufacturer's designation "heavy duty," Load Class "D" with perforations, and of width and thickness that fit recesses in channel sections.
 - 1) Material: Galvanized steel, reinforced perforated heel-safe grates.
 - 2) Locking Mechanism: Manufacturer's stainless steel locking device for securing grates to channel sections.
- c. Supports, Anchors, and Setting Devices: Manufacturer's standard securing brackets, U-shaped leg and securing bolts.
- d. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- e. ADA compliant to all directions of travel.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Assemble trench drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface. Provide for expansion joints as shown on platform.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

PART 1 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. This work will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 22 14 23.10

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SECTION 221429 – SUMP PUMP AND PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elevator sump pumps.
2. Sump pump piping.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Single-Seal Sump Pumps:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Liberty Pumps (ELV-Series) or comparable product by one of the following:
 - a. Liberty Pumps (Basis of Design).
 - b. Goulds Pumps; ITT Corporation.
 - c. Stancor, Inc.
 - d. Zoeller Company.
2. Elevator sump pump shall consist of a submersible cast iron pump with an epoxy finish. Impeller shall have a non-clogging vortex. Pump shall have 1-1/2 inch NPT discharge

and automatic reset thermal overload protection. Pump shall operate at 120 volts and pump 50 gpm with a 25 feet of head.

3. Pump shall have an oil smart switch that will disable the pump if oil is detected in the elevator sump and also activate audible and light alarms. Provide remote NEMA 4X panel enclosure No. 10-3163 with 50 feet of cord and a NEMA 4X alarm enclosure with 20 amp relay and a 10 ft. electric cord.

- a. Ball/Check Valve Combo in Pump Discharge Piping:

- 1) PVC plastic ball/check body by Liberty Pumps or approved equal.

2.2 PVC PIPE AND FITTINGS

- A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- C. Adhesive Primer: ASTM F 656.
- D. Solvent Cement: ASTM D 2564.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Pump Installation: Install in accordance with manufacturer's instruction.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 221429

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.

- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.

- 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 230513

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SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Grout.
3. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Approved equal.

B. Steel Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 GROUT

- A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.
- B. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.3 SILICONE SEALANTS

- A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dow Corning Corporation.
 - b. GE Construction Sealants; Momentive Performance Materials Inc.
 - c. Pecora Corporation.
 - d. Polymeric Systems, Inc.
 - e. Schnee-Morehead, Inc., an ITW company.
 - f. Approved equal.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - 3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.
- C. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

- D. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls Above Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.
 - 2. Concrete Slabs Above Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.
 - 3. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 230517

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SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. BrassCraft Manufacturing Co.; a Masco company.
 2. Dearborn Brass.
 3. Jones Stephens Corp.
 4. Keeney Manufacturing Company (The).
 5. Mid-America Fittings, Inc.
 6. Approved equal.

2.2 ESCUTCHEONS

- A. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
 - c. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.

3.2 FIELD QUALITY CONTROL

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 230518

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

B. Related Requirements:

1. Section 230548 "Vibration and Seismic Controls for HVAC".
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 - 3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Copper Pipe and Tube Hangers:
 - 1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
 - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. National Pipe Hanger Corporation or approved equal.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psi or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

- C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psi or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Empire Tool and Manufacturing Co, Inc.
 - b. Hilti, Inc.
 - c. MKT Fastening LLC.
 - d. Approved equal.
 - 2. Indoor Applications: Zinc-coated or stainless-steel.
 - 3. Outdoor Applications: Stainless steel.

2.6 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 MATERIALS

- A. Aluminum: ASTM B 221.
- B. Carbon Steel: ASTM A 1011.
- C. Structural Steel: ASTM A 36, carbon-steel plates, shapes, and bars; galvanized.
- D. Stainless Steel: ASTM A 240.
- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A 36, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Fastener System Installation:
 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger

and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- L. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - 5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.

- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 - 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 - 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 - 10. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 - 11. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - 12. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 - 13. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- N. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- P. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation mounts.
2. Housed-restrained-spring isolators.
3. Elastomeric hangers.
4. Snubbers.
5. Restraint channel bracings.
6. Restraint cables.
7. Seismic-restraint accessories.
8. Mechanical anchor bolts.
9. Adhesive anchor bolts.
10. Vibration isolation equipment bases.
11. Restrained isolation roof-curb rails.

1.2 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.
 - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic- and Wind-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
 - 1. Basic Wind Speed: 115 MPH.
 - 2. Building Classification Category: II.
 - 3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.
- B. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: D.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.
 - a. Component Importance Factor: 1.0.
 - b. Component Response Modification Factor: 3.0.
 - c. Component Amplification Factor: 3.0.
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.127.
 - 4. Design Spectral Response Acceleration at 1.0-Second Period: 0.053.

5. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts: <Insert drawing designation>.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Novia; A Division of C&P.
 - g. Vibration Eliminator Co., Inc.
 - h. Vibration Isolation.
 - i. Approved equal.
2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: <Insert drawing designation>.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.

- g. Vibration Isolation.
 - h. Approved equal.
- 2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
- 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.4 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: <Insert drawing designation>.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Novia; A Division of C&P.
 - g. Vibration Eliminator Co., Inc.
 - h. Approved equal.
 - 2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 - 3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.5 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Kinetics Noise Control, Inc.
 - 2. Mason Industries, Inc.

3. Novia; A Division of C&P.
4. Approved Equal.

- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

2.6 RESTRAINT CHANNEL BRACINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Approved Equal.

- B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.7 RESTRAINT CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gripple Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Novia; A Division of C&P.
5. Vibration & Seismic Technologies, LLC.
6. Approved Equal.

- B. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.8 SEISMIC-RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.

3. Mason Industries, Inc.
 4. Novia; A Division of C&P.
 5. TOLCO.
 6. Approved Equal.
- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.9 MECHANICAL ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. Hilti, Inc.
 3. Kinetics Noise Control, Inc.
 4. Approved Equal.
- B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.10 ADHESIVE ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hilti, Inc.
 2. Kinetics Noise Control, Inc.
 3. Approved Equal.
- B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.11 VIBRATION ISOLATION EQUIPMENT BASES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. California Dynamics Corporation.
 2. Kinetics Noise Control, Inc.
 3. Mason Industries, Inc.
 4. Novia; A Division of C&P.
 5. Vibration Eliminator Co., Inc.
 6. Vibration Isolation.
 7. Approved Equal.
- B. Steel Rails: Factory-fabricated, welded, structural-steel rails.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36. Rails shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

2.12 RESTRAINED ISOLATION ROOF-CURB RAILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ace Mountings Co., Inc.
 2. California Dynamics Corporation.
 3. Kinetics Noise Control, Inc.
 4. Mason Industries, Inc.
 5. Novia; A Division of C&P.
 6. Approved Equal.
- B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.
- C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.

- D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
- E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.
- F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

- C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- D. Equipment Restraints:
 - 1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.
- E. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.
- H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- K. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232300 "Refrigerant Piping" for piping flexible connectors.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of

Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.
3. Valve tags.
4. Warning tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Division 01 specifications.

2.2 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Brady Corporation.
 2. Carlton Industries, LP.
 3. Champion America.
 4. Craftmark Pipe Markers.

5. Approved equal.
 6. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 7. Letter Color: Black.
 8. Background Color: White.
 9. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 10. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 11. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 12. Fasteners: Stainless-steel rivets or self-tapping screws.
 13. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Brady Corporation.
 2. Carlton Industries, LP.
 3. Champion America.
 4. Craftmark Pipe Markers.
 5. Approved equal.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 2. Lettering Size: Size letters according to ASME A13.1 for piping.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in elevator machine rooms.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- C. Pipe Label Color Schedule:
 - 1. Refrigerant Piping: Black letters on a safety-orange background.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Refrigerant: 1-1/2 inches, round.
 - 2. Valve-Tag Colors:
 - a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.

3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 230553

SECTION 230719 - HVAC PIPING INSULATION

1.1 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Condensate drain piping, indoors and outdoors.
 - 2. Refrigerant suction and hot-gas piping, indoors and outdoors.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 3. Detail removable insulation at piping specialties.
 - 4. Detail application of field-applied jackets.
 - 5. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Airex Manufacturing.
 - c. Armacell LLC.
 - d. Approved equal.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Approved equal.

2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Approved equal.
 - 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Knauf Insulation.
 - e. Mon-Eco Industries, Inc.
 - f. Approved equal.
 - 2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Approved equal.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

2.5 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. ITW Insulation Systems; Illinois Tool Works, Inc.
 - b. Approved equal.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper
 - d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

e. Factory-Fabricated Fitting Covers:

- 1) Same material, finish, and thickness as jacket.
- 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
- 3) Tee covers.
- 4) Flange and union covers.
- 5) End caps.
- 6) Beveled collars.
- 7) Valve covers.
- 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.6 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. ITW Insulation Systems; Illinois Tool Works, Inc.
 - b. Approved equal.
2. Stainless Steel: ASTM A 167 or ASTM A 240, Type 304; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

- a. For below-ambient services, apply vapor-barrier mastic over staples.
- 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
- 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install

- insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of

inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, and three locations of threaded valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F:

- 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch thick.

- B. Refrigerant Suction and Hot-Gas Piping:

- 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch thick.

- C. Refrigerant Suction and Hot-Gas Flexible Tubing:

- 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch thick.

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping:

- 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 2 inches thick.

- B. Refrigerant Suction and Hot-Gas Flexible Tubing:

- 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 2 inches thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
- D. Piping, Exposed:
 - 1. Aluminum, Corrugated: 0.020 inch thick.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping:
 - 1. Aluminum, Corrugated: 0.024 inch thick.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITY SUMMARY of the plans.

END OF SECTION 230719

SECTION 230923.01 - ELECTRICAL WORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Providing electrical work as shown and specified herein. Electrical work shall include but not be limited to:

1. Signal wiring to instrumentation and field devices, and for low voltage and line voltage analog and digital input and output signals.
2. 120 volt wiring for field device and instrument requiring 120 Vac power to operate properly (e.g., nonloop power instrument).
3. Internal wiring of control panels provided.
4. Certain 120 volt wiring will be provided by the Division 26 Contractor as shown. Otherwise, provide 120 volt wiring in conduit as shown and as required.

- B. Related Sections

1. Section 230923.1 Control Dampers.
2. Section 233423 HVAC Power Ventilators
3. Section 238129 Variable-Refrigerant-Flow HVAC Systems
4. Section 284400 Refrigerant Detection & Alarm.

1.2 REFERENCES

- A. NEC - National Electrical Code.
- B. NEMA - National Electrical Manufacturers Association.
- C. UL - Underwriters Laboratories Inc.
- D. IEEE - Institute of Electrical and Electronic Engineers.
- E. OSHA - Occupational Safety and Health Act.
- F. ANSI - American National Standards Institute.
- G. ASME - American Society of Mechanical Engineers.

1.3 DEFINITIONS

- A. Vac - volts alternating current.
- B. Vdc - volts direct current.

1.4 SUBMITTALS

- A. Submit data sheet on each type of wire to be used and its specific job application (e.g., signal wiring).
- B. Statement that the Contractor has reviewed Division 26 Specifications and will comply with its requirements for conduit and wiring installation.
- C. Statement on compliance with grounding and power conditioning.
- D. Statement of 120 volt wiring responsibility of Controls Contractor as it applies to Control System interface and interlock wiring. Also, the Contractor shall state where he shall provide 120 volt wiring.
- E. Equipment data sheets.

1.5 GROUNDING AND POWER CONDITIONING

- A. Where grounding and power conditioning requirements of System hardware equipment specified in Section 284400 Refrigerant Detection & Alarm, exceed grounding and power conditioning as shown and specified to be provided by Division 26 Contractor, this Contractor shall furnish and install additional grounding cables, rods, power conditioning devices, signal conditioning devices, surge protection devices, as required for proper operation of the System hardware equipment at no additional cost to the Owner.
- B. Wiring shall be provided in conduit. Devices and equipment shall be mounted in minimum NEMA 1 enclosures.
- C. If additional grounding and power conditioning are required, the Contractor shall, within 60 days of award of the Contract, notify the Engineer in writing for approval.

PART 2 - PART 2 PRODUCTS

2.1 GENERAL

- A. Conduit and all wiring shall be furnished in accordance with requirements of Division 26, and in accordance with latest revision of the National Electrical Code and applicable state and local codes.

2.2 SIGNAL WIRING

- A. Low voltage (40 volts and less) signal wiring to analog and digital instrumentation and field devices shall be minimum 18 gauge, twisted cable, plenum rated as follows:
 - 1. Belden #88760 for instrumentation and field devices requiring two wires.
 - 2. Belden #88770 for instrumentation and field devices requiring three wires.

- B. Line voltage (greater than 40 volts) signal wiring to analog and digital instrumentation and field devices shall be:
 - 1. Minimum 14 gauge THHN.

PART 3 - PART 3 EXECUTION

3.1 GENERAL

- A. All wiring shall be plenum rated where located above a ceiling and installed in conduit in all other areas. Conduit and all wiring shall be installed in accordance with requirements of Division 26 and in accordance with latest revision of NEC and applicable state and local codes.

3.2 SIGNAL WIRING

- A. Low voltage signal wiring shields shall be grounded at control panel end or as recommended by instrument/device manufacturer.
- B. Low voltage and line voltage signal wiring shall be run with no splices or intermediate terminations.
- C. Low voltage signal wiring shall be run in separate conduit from wiring over 40 volts.

3.3 TESTING

- A. Test electrical circuits and wiring covered by this Specification and prove these circuits and wiring to be free from grounds and short circuits, including but not limited to, low and medium voltage circuits. Necessary adjustments to equipment, circuits and wiring shall be made to correct defects and faults.
- B. The Contractor shall indicate by letter to the Owner's Representative on company letterhead that above testing has been successfully completed and submit documented test results to the Owner's Representative for review.
- C. Furnish instruments, ladders, lubricants, test equipment and personnel required for test. The Owner will provide electrical power for tests scheduled with his advanced approval.
- D. Testing procedures specified above represent minimum requirements. Specific test shall be made if required by applicable codes and jurisdictional authorities.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIES SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement

and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

- B. Erosion and Sediment Control will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 230923.01

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SECTION 230923.01 - ELECTRICAL WORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Providing electrical work as shown and specified herein. Electrical work shall include but not be limited to:

1. Signal wiring to instrumentation and field devices, and for low voltage and line voltage analog and digital input and output signals.
2. 120 volt wiring for field device and instrument requiring 120 Vac power to operate properly (e.g., nonloop power instrument).
3. Internal wiring of control panels provided.
4. Certain 120 volt wiring will be provided by the Division 26 Contractor as shown. Otherwise, provide 120 volt wiring in conduit as shown and as required.

- B. Related Sections

1. Section 230923.1 Control Dampers.
2. Section 233423 HVAC Power Ventilators
3. Section 238129 Variable-Refrigerant-Flow HVAC Systems
4. Section 284400 Refrigerant Detection & Alarm.

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- A. NEC - National Electrical Code.
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- A. Vac - volts alternating current.
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1.4 SUBMITTALS

- A. Submit data sheet on each type of wire to be used and its specific job application (e.g., signal wiring).
- B. Statement that the Contractor has reviewed Division 26 Specifications and will comply with its requirements for conduit and wiring installation.
- C. Statement on compliance with grounding and power conditioning.
- D. Statement of 120 volt wiring responsibility of Controls Contractor as it applies to Control System interface and interlock wiring. Also, the Contractor shall state where he shall provide 120 volt wiring.
- E. Equipment data sheets.

1.5 GROUNDING AND POWER CONDITIONING

- A. Where grounding and power conditioning requirements of System hardware equipment specified in Section 284400 Refrigerant Detection & Alarm, exceed grounding and power conditioning as shown and specified to be provided by Division 26 Contractor, this Contractor shall furnish and install additional grounding cables, rods, power conditioning devices, signal conditioning devices, surge protection devices, as required for proper operation of the System hardware equipment at no additional cost to the Owner.
- B. Wiring shall be provided in conduit. Devices and equipment shall be mounted in minimum NEMA 1 enclosures.
- C. If additional grounding and power conditioning are required, the Contractor shall, within 60 days of award of the Contract, notify the Engineer in writing for approval.

PART 2 - PART 2 PRODUCTS

2.1 GENERAL

- A. Conduit and all wiring shall be furnished in accordance with requirements of Division 26, and in accordance with latest revision of the National Electrical Code and applicable state and local codes.

2.2 SIGNAL WIRING

- A. Low voltage (40 volts and less) signal wiring to analog and digital instrumentation and field devices shall be minimum 18 gauge, twisted cable, plenum rated as follows:
 - 1. Belden #88760 for instrumentation and field devices requiring two wires.
 - 2. Belden #88770 for instrumentation and field devices requiring three wires.

- B. Line voltage (greater than 40 volts) signal wiring to analog and digital instrumentation and field devices shall be:
 - 1. Minimum 14 gauge THHN.

PART 3 - PART 3 EXECUTION

3.1 GENERAL

- A. All wiring shall be plenum rated where located above a ceiling and installed in conduit in all other areas. Conduit and all wiring shall be installed in accordance with requirements of Division 26 and in accordance with latest revision of NEC and applicable state and local codes.

3.2 SIGNAL WIRING

- A. Low voltage signal wiring shields shall be grounded at control panel end or as recommended by instrument/device manufacturer.
- B. Low voltage and line voltage signal wiring shall be run with no splices or intermediate terminations.
- C. Low voltage signal wiring shall be run in separate conduit from wiring over 40 volts.

3.3 TESTING

- A. Test electrical circuits and wiring covered by this Specification and prove these circuits and wiring to be free from grounds and short circuits, including but not limited to, low and medium voltage circuits. Necessary adjustments to equipment, circuits and wiring shall be made to correct defects and faults.
- B. The Contractor shall indicate by letter to the Owner's Representative on company letterhead that above testing has been successfully completed and submit documented test results to the Owner's Representative for review.
- C. Furnish instruments, ladders, lubricants, test equipment and personnel required for test. The Owner will provide electrical power for tests scheduled with his advanced approval.
- D. Testing procedures specified above represent minimum requirements. Specific test shall be made if required by applicable codes and jurisdictional authorities.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Pay-

ment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

- B. Erosion and Sediment Control will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 230923.01

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SECTION 230923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of control dampers and actuators:

1. Rectangular control dampers.
2. General control-damper actuator requirements.
3. Electric and electronic actuators.

B. Related Requirements:

1. Section 230923.01 "Electrical Work"

1.2 DEFINITIONS

A. DDC: Direct-digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control dampers and actuators, including the following.
 - a. Flow at project design and minimum flow conditions.
 - b. Face velocity at project design and minimum airflow conditions.
 - c. Pressure drop across damper at project design and minimum airflow conditions.
 - d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - e. Maximum close-off pressure.
 - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Product installation location shown in relationship to room, duct, and equipment.
 2. Size and location of wall access panels for control dampers and actuators installed behind walls.
 3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Delegated Design: Engage a qualified professional, as defined in Division 01 specifications.
- D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

F. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

G. Selection Criteria:

1. Control dampers shall be suitable for operation at following conditions:
 - a. Outdoor Air: 0°F-104°F, 2 inch w.g.
2. Fail positions unless otherwise indicated:
 - a. Outdoor Air: Open.
3. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
4. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

H. Insulated Rectangular Dampers:

1. Manufactured by:
 - a. Tamco
 - b. Approved equal.
2. Performance:
 - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure and shall not exceed 4.9 cfm/sq. ft. against 4-in. wg differential static pressure at minus 40 deg F.
 - b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
 - c. Velocity: Up to 4000 fpm.
 - d. Temperature: Minus 100 to plus 185 deg F.
 - e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - f. Damper shall have AMCA seal for both air leakage and air performance.
3. Construction:
 - a. Frame:
 - 1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.08 inch thick.
 - 2) C-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
 - 3) Width not less than 4 inches.

- 4) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
 - 5) Damper frame shall be insulated with polystyrofoam on four sides.
- b. Blades:
- 1) Hollow shaped, extruded aluminum.
 - 2) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
 - 3) Parallel or opposed blade configuration as required by application.
 - 4) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.08 inch thick.
 - 5) Width not to exceed 6 inches.
 - 6) Length as required by close-off pressure, not to exceed 48 inches.
- c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.
- d. Axles: 0.44-inch- diameter plated or stainless steel, mechanically attached to blades.
- e. Bearings:
- 1) Bearings shall be composed of a Celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
- 1) Concealed in frame.
 - 2) Constructed of aluminum and plated or stainless steel.
 - 3) Hardware: Stainless steel.
- g. Transition:
- 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - 3) Damper size and sleeve shall be connection size plus 2 inches.
 - 4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
 - 5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

- 1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
- 2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

2.2 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

- A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.
- B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.
- C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
- D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
- E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
- F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
- G. Provide mounting hardware and linkages for connecting actuator to damper.
- H. Select actuators to fail in desired position in the event of a power failure.
- I. Actuator Fail Positions: As indicated below:
 1. Outdoor Air: Open.

2.3 ELECTRIC AND ELECTRONIC ACTUATORS

- A. Type: Motor operated, with or without gears, electric and electronic.
- B. Voltage:
 1. Voltage selection is delegated to professional designing control system] [24 V] [120 V].
 2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.
- C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- D. Field Adjustment:
1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
 2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- E. Two-Position Actuators: Single direction, spring return or reversing type.
- F. Position Feedback:
1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
 2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
- G. Fail-Safe:
1. Where indicated, provide actuator to fail to an end position.
 2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
 3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.
- H. Integral Overload Protection:
1. Provide against overload throughout the entire operating range in both directions.
 2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
- I. Damper Attachment:
1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
 2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
 3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

J. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

K. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

L. Stroke Time:

1. Operate damper from fully closed to fully open within 15 seconds.
2. Operate damper from fully open to fully closed within 60 seconds.
3. Move damper to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

M. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.

- B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert valve> force.
- C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Seal penetrations made in fire-rated and acoustically rated assemblies.
- E. Fastening Hardware:
 - 1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- G. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they will be subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Within 15 miles of sea coast
 - 3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
 - 4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

- A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.
- B. Clearance:
 - 1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
 - 2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.
- C. Service Access:
 - 1. Dampers and actuators shall be accessible for visual inspection and service.
 - 2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."
- D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.
- E. Attach actuator(s) to damper drive shaft.
- F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 CONNECTIONS

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with damper identification on damper.

3.7 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
6. Verify that control dampers are installed correctly for flow direction.
7. Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Verify that damper frame attachment is properly secured and sealed.
9. Verify that damper actuator and linkage attachment are secure.
10. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
11. Verify that damper blade travel is unobstructed.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING:

- A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.
- C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of

Measurement and Payment” description as included in PAY ITEM DESCRIPTION &
QUANTITIY SUMMARY of the plans.

END OF SECTION 230923.12

SECTION 232300 - REFRIGERANT PIPING

1.1 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:

B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show interface and spatial relationships between piping and equipment.
3. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Working Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

- A. Service Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.

- d. Parker Hannifin Corp.
 - e. Paul Mueller Company.
 - f. Approved equal.
- 2. Body: Forged brass with brass cap including key end to remove core.
 - 3. Core: Removable ball-type check valve with stainless-steel spring.
 - 4. Seat: Polytetrafluoroethylene.
 - 5. End Connections: Copper spring.
 - 6. Working Pressure Rating: 500 psig.

2.4 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arkema Inc.
 - b. DuPont Fluorochemicals Div.
 - c. Genetron Refrigerants; Honeywell International Inc.
 - d. Approved equal.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Hot-Gas and Liquid Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
- C. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- B. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss,

expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in elevator machine rooms.
- D. Install piping indicated to be exposed and piping in elevator machine rooms at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.
- L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- M. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- P. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

- R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.

3.5 HANGERS AND SUPPORTS

- A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.

- c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Evacuate indoor unit and the interconnecting pipe from the service port on the liquid and gas pipes with a vacuum pump to 0.0943 psi. If vacuum holds for 12 hours, system is ready for charging.
 - 2. Follow manufacturer's installation instructions found in the outdoor unit Installation Manual.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Verify that compressor oil level is correct.
 - 2. Open compressor suction and discharge valves.
 - 3. Open refrigerant valves except bypass valves that are used for other purposes.
 - 4. Check open compressor-motor alignment and verify lubrication for motors and bearings.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- B. Erosion and Sediment Control will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION &

QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Sheet metal materials.
3. Sealants and gaskets.
4. Hangers and supports.

1.2 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Sealants and gaskets.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 2. Suspended ceiling components.
 3. Structural members to which duct will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Penetrations of smoke barriers and fire-rated construction.
- B. Welding certificates.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Reinforcement Shapes and Plates: ASTM A 36, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. VOC: Maximum 75 g/L (less water).
 - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Flanged Joint Sealant: Comply with ASTM C 920.
 1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
- D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports:
 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

- A. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

- B. Building Attachments: Concrete inserts, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
 - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.8 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - 6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
- B. Supply Ducts:
 1. Ducts Connected to Constant-Volume Air-Handling Units SSAC-1, 2, 3:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 6.
- C. Intermediate Reinforcement:
 1. Galvanized-Steel Ducts: Galvanized steel.
- D. Elbow Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- E. Branch Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

- B. Erosion and Sediment Control will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flange connectors.
2. Duct-mounted access doors.
3. Flexible connectors.
4. Duct accessory hardware.

B. Related Requirements:

1. Section 233423 "Power Ventilators".

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Hardcastle, Inc
 - 3. Ward Industries; a brand of Hart & Cooley
 - 4. Approved Equal.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.4 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. McGill AirFlow LLC
 - 3. Pottorff
 - 4. Ward Industries; a brand of Hart & Cooley
 - 5. Approved Equal.

- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

- a. Double wall, rectangular.
- b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
- c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
- d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

- a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
- b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.

2.5 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ward Industries; a brand of Hart & Cooley
4. Approved Equal.

- B. Materials: Flame-retardant or noncombustible fabrics.

- C. Coatings and Adhesives: Comply with UL 181, Class 1.

- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

2.6 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install test holes at fan inlets and outlets and elsewhere as indicated.
- D. Install duct access doors on sides of ducts, inlet plenum and exhaust plenum to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. At outdoor-air intakes and exhaust-air plenums.
 - 2. Downstream from manual volume dampers.
 - 3. Elsewhere as indicated.
- E. Install access doors with swing against duct static pressure.
- F. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches. Intake plenum.
 - 2. Head and Hand Access: 18 by 10 inches. Exhaust plenum.
- G. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- H. Install flexible connectors to connect ducts to equipment.
- I. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- J. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect locations of access doors and verify that purpose of access door can be performed.
 - 3. Inspect turning vanes for proper and secure installation.

PART 4 - MEASUREMENT AND PAYMENT

4.01 DESCRIPTION

- A. Site Clearing will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

- B. Erosion and Sediment Control will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line centrifugal fans.

1.2 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
- B. Operating Limits: Classify according to AMCA 99.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
 1. Certified fan performance curves with system operating conditions indicated.
 2. Certified fan sound-power ratings.
 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 4. Material thickness and finishes, including color charts.
 5. Dampers, including housings, linkages, and operators.
 6. Fan speed controllers.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Roof framing and support members relative to duct penetrations.
 - 2. Ceiling suspension assembly members.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Engineering & Manufacturing Corp.

2. Greenheck Fan Corporation.
 3. Loren Cook Company.
 4. PennBarry.
 5. Approved equal.
- B. Housing: Galvanized steel housing, inlet flange, outlet duct collar with integral backdraft damper, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- D. Fan Wheels: Forward curved polypropylene.
- E. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
- F. Capacities and Characteristics: As scheduled on drawings.
1. Vibration Isolators:
 - a. Type: Spring hangers with vertical limit stops.
 - b. Static Deflection: 1 inch.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Enclosure Type: Totally enclosed, fan cooled.

2.3 SOURCE QUALITY CONTROL

- A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch. Vibration-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- D. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Replace fan and motor pulleys as required to achieve design airflow.
- D. Lubricate bearings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 233423

SECTION 238129 – VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:
 - 1. Indoor, exposed, floor-mounted units.
 - 2. Outdoor, air-source, heat-pump units.
 - 3. System controls.
 - 4. System refrigerant and oil.
 - 5. Metal hangers and supports.
 - 6. Metal framing systems.
 - 7. Fastener systems.
 - 8. Pipe stands.
 - 9. Miscellaneous support materials.
 - 10. Piping and tubing insulation.
 - 11. System control cable and raceways.

1.2 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- D. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- E. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.
- F. VRF: Variable refrigerant flow.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit control.
6. Include description of control software features.
7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
8. Include refrigerant type and data sheets showing compliance with requirements indicated.
9. For system design software.
10. Indicate location and type of service access.

B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.

4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Service access panels.

B. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 - a. Retain copies of Installer certificates on-site and make available on request.
2. For VRF HVAC system manufacturer.
3. For VRF HVAC system provider.

C. Product Certificates: For each type of product.

D. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranties: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters:
 - a. One set(s) for each unit with replaceable filters.
 - b. One set(s) for each unit type and unique size of washable filters.
 2. Controllers for Indoor Units: One for each unique controller type installed.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Nationally recognized manufacturer of VRF HVAC systems and products.
 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
 3. VRF HVAC systems and products that have been successfully tested and in use on at least three completed projects.
 4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
 - e. Owner training.
- B. Factory-Authorized Service Representative Qualifications:
1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
 2. In-place facility located within 60 miles of Project.
 3. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 4. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - a. Each person assigned to Project shall have demonstrated past experience.
 5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 6. Service and maintenance staff assigned to support Project during warranty period.
 7. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
 8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

- C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.
 - 1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 - 2. Installer certification shall be valid and current for duration of Project.
 - 3. Retain copies of Installer certificates on-site and make available on request.
 - 4. Each person assigned to Project shall have demonstrated past experience.
 - a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - 5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.
- D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
- E. Replace installed products damaged during construction.

1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation.

- c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
- 2. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: Five year(s) from date of Substantial Completion.
 - c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Corporation; a unit of United Technologies Corp.
 - 2. Daikin AC (Americas), Inc.
 - 3. Johnson Controls, Inc.
 - 4. LG Electronics.
 - 5. Mitsubishi Electric & Electronics USA, Inc.
 - 6. Samsung HVAC.
 - 7. Approved equal.
- B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:
 - 1. Indoor and outdoor units, including accessories.
 - 2. Controls and software.
 - 3. Refrigerant isolation valves.
 - 4. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

- A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.
 - 1. Two-pipe system design.
 - 2. System(s) operation, air-conditioning as indicated on Drawings.
 - 3. Each system with one refrigerant circuit shared by all indoor units connected to system.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. AHRI Compliance: System and equipment performance certified according to AHRI 1230.
- D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
 2. ASHRAE 135: For control network protocol with remote communication.
 3. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.
- E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.
1. Provide system refrigerant calculations.
 - a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
 - b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.
 2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
 3. System Refrigerant Piping and Tubing:
 - a. Arrangement: Arrange piping to interconnect indoor units and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
 - b. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.
 4. System Controls:
 - a. Network arrangement.
 - b. Network interface with other building systems.
 - c. Product selection.
 - d. Sizing.

B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. Isolation of Equipment: Provide isolation valves to isolate each indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

E. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than 83 percent.
2. Not more than 110 percent.
3. Range acceptable to manufacturer.

F. System Turndown: Stable operation down to 40 percent of outdoor-unit capacity.

G. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.
 - a. Design equipment and supports to withstand wind loads of governing code and ASCE/SEI 7.
 - b. Design equipment and supports to withstand snow and ice loads of governing code.
 - c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.
2. Maximum System Operating Outdoor Temperature: See Drawings.
3. Minimum System Operating Outdoor Temperature: 5-degrees F.

H. Seismic Performance: VRF HVAC system(s) shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
 2. Component Importance Factor: 1.0
 3. Component Response Modification Factor: 3.0.
 4. Component Amplification Factor: 3.0.
- I. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.
1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
 2. Outdoor: Within ordinance of governing authorities.
- J. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
- K. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, SUSPENDED, CEILING CASSETTE UNITS

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
- B. Cabinet:
1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
 2. Mounting: Manufacturer-designed provisions for field installation.
 3. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. DX Coil Assembly:
1. Coil Casing: Aluminum, galvanized, or stainless steel.
 2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 3. Coil Tubes: Copper, of diameter and thickness required by performance.
 4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 5. Internal Tubing: Copper tubing with brazed joints.
 6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 7. Field Piping Connections: Manufacturer's standard.
 8. Factory Charge: Dehydrated air or nitrogen.
 9. Testing: Factory pressure tested and verified to be without leaks.
- D. Drain Assembly:
1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.

2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 3. Field Piping Connection: Non-ferrous material.
- E. Fan and Motor Assembly:
1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d. Wheels statically and dynamically balanced.
 2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Filter Assembly:
1. Access: Bottom, to accommodate filter replacement without the need for tools.
 2. Efficiency: ASHRAE 52.2, MERV 10.
 3. Media:
 - a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b. Washable: Manufacturer's standard filter with antimicrobial treatment.
- G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.
1. Discharge Pattern: Four-way throw.
 - a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
 - b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.
 2. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.
- H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.
- I. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
- J. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: Unit inlet air temperature, Coil entering refrigerant temperature, Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Four for use in customizable control strategies.
 - b. Digital Inputs: Four for use in customizable control strategies.
 - c. Digital Outputs: Four for use in customizable control strategies.
5. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode , manual operation mode , filter service notification, drain assembly high water level safety shutdown and notification , run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

K. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.5 OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.
 - a. Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.
 3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. Compressor and Motor Assembly:
1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 40 percent of rated capacity.
 2. Protection: Integral protection against the following:
 - a. High refrigerant pressure.
 - b. High oil temperature.
 - c. Thermal and overload.
 3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
 4. Vibration Control: Integral isolation to dampen vibration transmission.
 5. Oil management system to ensure safe and proper lubrication over entire operating range.
 6. Crankcase heaters with integral control to maintain safe operating temperature.
 7. Fusible plug.
- D. Condenser Coil Assembly:
1. Plate Fin Coils:
 - a. Casing: Aluminum, galvanized, or stainless steel.
 - b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
 - c. Tubes: Copper, of diameter and thickness required by performance.
 2. Corrosion Protection: Coating with documented salt spray test performance of 1000hours according ASTM B 117 surface scratch test (SST) procedure.
- E. Condenser Fan and Motor Assembly:
1. Fan(s): Propeller type.
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - c. Statically and dynamically balanced.
 2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
 3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
 4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
 6. Vibration Control: Integral isolation to dampen vibration transmission.

- F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- G. Unit Controls:
 - 1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 - 2. Factory-Installed Controller: Configurable digital control.
 - 3. Factory-Installed Sensors:
 - a. Inverter circuit over heat protection and overcurrent protection.
 - b. Refrigerant discharge temperature.
 - c. Refrigerant high pressure.
 - 4. Features and Functions: error code notification, filter maintenance notification.
 - 5. Communication: Network communication with indoor units and other outdoor unit(s).
 - 6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- H. Unit Electrical:
 - 1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 - 2. Field Connection: Single point connection to power entire unit and integral controls.
 - 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.
- I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for 1000 hours according ASTM B 117.
- J. Unit Piping:
 - 1. Unit Tubing: Copper tubing with brazed joints.
 - 2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3. Field Piping Connections: Manufacturer's standard.
 - 4. Factory Charge: Dehydrated air or nitrogen.
 - 5. Testing: Factory pressure tested and verified to be without leaks.

2.6 SYSTEM CONTROLS

- A. General Requirements:

1. Network: Indoor units and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer proprietary or open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
 - a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
 - b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
 - c. Integration shall include control, monitoring, scheduling, change of value notifications.
4. Operator Interface:
 - a. Operators shall interface with system and unit controls through the following:
 - 1) Operator interfaces integral to controllers.
 - 2) Owner-furnished PC connected to central controller(s).
 - 3) Web interface through web browser software.
 - 4) Integration with Building Automation System.
 - b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:
 - 1) On/off control.
 - 2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
6. Displays service notifications and error codes.
7. Monitors and displays cumulative operating time of indoor units.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display.
10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.
 - a. Include multiple interconnected controllers as required.
2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - a. Sets schedule for daily, weekly, and annual events.
 - b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.
4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel.

D. Wired Controllers for Indoor Units:

1. Temperature Units: Fahrenheit and Celsius.
2. On/Off: Turns indoor unit on or off.
3. Hold: Hold operation settings until hold is released.
4. Operation Mode: Cool, Auto, Dehumidification, Fan Only.
5. Temperature Display: 1-degree increments.
6. Temperature Set-Point: Separate set points for Cooling. Adjustable in 1-degree increments between 50-90 degree F..
7. Relative Humidity Display: 1 percent increments.
8. Relative Humidity Set-Point: Adjustable in 1 percent increments between 45-60.
9. Fan Speed Setting: Select between available options furnished with the unit.
10. Service Notification Display: "Filter".
11. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
12. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
13. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
14. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.7 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. R-410a.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.8 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: According to ASTM B 88, Type L.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.
4. Solder Filler Metals: ASTM B 32, lead-free alloys, and water-flushable flux according to ASTM B 813.

2.9 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

2.10 METAL HANGERS AND SUPPORTS

A. Copper Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.11 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Flex-Strut Inc.
 - c. G-Strut.

- d. Haydon Corporation.
 - e. MIRO Industries.
 - f. Thomas & Betts Corporation; A Member of the ABB Group.
 - g. Unistrut; Part of Atkore International.
 - h. Approved equal.
- 2. Description: Shop- or field-fabricated, pipe-support assembly for supporting multiple parallel pipes.
 - 3. Standard: MFMA-4.
 - 4. Channels: Continuous slotted steel channel with inturned lips.
 - 5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
 - 7. Metallic Coating for Use Indoors: Electroplated zinc.

2.12 FASTENER SYSTEMS

- A. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Indoor Applications: Zinc-coated or stainless steel.
 - 2. Outdoor Applications: Stainless steel.

2.13 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Stainless steel.
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 2. Bases: One or more; plastic.
 3. Vertical Members: Two or more protective-coated-steel channels.
 4. Horizontal Member: Protective-coated-steel channel.
 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.14 MISCELLANEOUS SUPPORT MATERIALS

- A. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.
- B. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; galvanized.
- C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.15 PIPING AND TUBING INSULATION

- A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.
- B. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

2.16 SYSTEM CONTROL CABLE

- A. Cable Rating: Listed and labeled for application according to NFPA 70.
1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - a. Flame Travel Distance: 60 inches or less.
 - b. Peak Optical Smoke Density: 0.5 or less.
 - c. Average Optical Smoke Density: 0.15 or less.
 2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
 3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

- B. Low-Voltage Control Cabling:
 - 1. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: Comply with NFPA 262.
- C. TIA-485A Network Cabling:
 - 1. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: NFPA 262.
- D. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors.
 - 1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
 - 2. Conductors: 100-ohm, 23 AWG solid copper.
 - 3. Shielding: Shielded twisted pairs (FTP).
 - 4. Cable Rating: By application.
 - 5. Jacket: Gray thermoplastic.
- E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.17 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect factory-assembled equipment.
- B. Equipment will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

- A. Clearance:
 - 1. Maintain manufacturer's recommended clearances for service and maintenance.
 - 2. Maintain clearances required by governing code.
- B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
 - 1. Loose components shall be installed by manufacturer's service representative or system Installer under supervision of manufacturer's service representative.

3.3 INSTALLATION OF INDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.
- C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

- D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
- E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- G. Suspended units located in elevator machine rooms.

3.4 INSTALLATION OF OUTDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping and tubing to permit valve servicing.
- F. Install piping and tubing at indicated slopes.
- G. Install piping and tubing free of sags.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping and tubing to allow application of insulation.
- J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.
- K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

- L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
 - a. Details indicated on Drawings.
 - b. Manufacturer's requirements.
 - c. Governing codes.
 - d. In the absence of requirements, comply with requirements of ASHRAE handbooks.
4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than two percent.

3.7 INSTALLATION OF REFRIGERANT PIPING

A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet. Minimum rod size, 3/8 inch.
3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

B. Install refrigerant piping according to ASHRAE 15 and governing codes.

C. Select system components with pressure rating equal to or greater than system operating pressure.

D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection.

F. Install refrigerant piping and tubing in protective conduit where installed belowground.

G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps to entrain oil in vertical runs.
4. Liquid lines may be installed level.

I. When brazing, remove or protect components that could be damaged by heat.

J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.

K. Joint Construction:

1. Ream ends of tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.

3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- C. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- D. Fastener System Installation:
 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
 2. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.
- E. Pipe Stand Installation:
 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel.
 1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- L. Piping and Tubing Insulation:
 - 1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 2. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
- M. Horizontal-Piping Hangers and Supports: Install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
 - 5. Pipe stands for horizontal pipes located outdoors.
 - 6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- N. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
 - 1. Sizes through NPS 3/4: Maximum span, 5 feet; minimum rod size, 3/8 inch.
 - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
- O. Vertical-Piping Clamps: Install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8).
- P. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 5 feet.
- Q. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- R. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- S. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- T. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inch.
- U. Hanger-Rod Attachments: Install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

V. Building Attachments: Install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.9 INSTALLATION OF PIPING AND TUBING INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

- A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
- B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."

3.11 ELECTRICAL INSTALLATION

- A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.
 1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.
- C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

- F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.
 - 2. Locate nameplate or label where easily visible.
- G. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.
 - 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
 - 2. Outlet boxes for cables shall be no smaller than 4 inches square by 1-1/2 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
 - 3. Flexible metal conduit shall not be used.
- H. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- I. Install manufactured conduit sweeps and long-radius elbows if possible.
- J. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.12 SOFTWARE

- A. Cybersecurity:
 - 1. Software:
 - a. Coordinate security requirements with IT department <Insert entity responsible for IT security>.
 - b. Ensure that latest stable software release is installed and properly operating.
 - c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.
 - 2. Hardware:
 - a. Coordinate location and access requirements with IT department <Insert entity responsible for IT security>.
 - b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
 - c. Disable dual network connections.

3.13 INSTALLATION OF SYSTEM CONTROL CABLE

- A. Comply with NECA 1.

B. Installation Method:

1. Install cables in raceways except as follows:
 - a. Within equipment and associated control enclosures.
 - b. In accessible ceiling spaces where open cable installation method may be used.
2. Conceal raceway and cables except in unfinished spaces.

C. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.
5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
 2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.
- F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.14 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.15 GROUNDING INSTALLATION

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.16 IDENTIFICATION

- A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.17 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
 1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.
 - a. First Visit: Kick-off meeting.
 - b. Second Visit: At approximately 25 percent completion of system(s).
 - c. Third Visit: At approximately 50 percent completion of system(s).
 - d. Fourth Visit: At approximately 75 percent completion of system(s).
 - e. Fifth Visit: Final inspection before system startup.
3. Kick-off Meeting:
 - a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
 - b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
 - c. Meeting shall cover the following as a minimum requirement:
 - 1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
 - 2) Manufacturer's installation requirements specific to systems being installed.
 - 3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
 - 4) Required field activities related installation of VRF HVAC system.
 - 5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.
4. Site Visits: Activities for each site visit shall include the following:
 - a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
 - b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
 - c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
 - d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
 - e. Issue a report for each visit, documenting the visit.
 - 1) Report to include name and contact information of individual making the visit.
 - 2) Date(s) and time frames while on-site.
 - 3) Names and contact information of people meeting with while on-site.
 - 4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:

- a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
- b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
- c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
- d. Inspection reports for indoor units shall include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Unit airflow direction within an acceptable range.
 - 19) If applicable, fan external static pressure setting.
 - 20) Filter type and condition acceptable.
 - 21) Noise level within an acceptable range.
 - 22) Refrigerant piping properly connected and insulated.
 - 23) Condensate drain piping properly connected and insulated.
 - 24) If applicable, ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- e. Inspection reports for outdoor units shall include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.

- 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Condensate removal acceptable.
 - 13) Noise level within an acceptable range.
 - 14) Refrigerant piping properly connected and insulated.
 - 15) Condensate drain piping properly connected and insulated.
 - 16) Remarks.
- f. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
 - g. Installer shall correct observed deficiencies found by the inspection.
 - h. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
 - i. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
 - j. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.
- B. Perform the following tests and inspections with the assistance of manufacturer's service representative:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Refrigerant Tubing Positive Pressure Testing:
1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
 2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.2 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen.
 3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
 4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.

- f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
 5. Submit test reports for Project record.
- D. Refrigerant Tubing Evacuation Testing:
1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
 2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
 3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
 4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks.
 5. Submit test reports for Project record.
 6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.
- E. System Refrigerant Charge:
1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
 2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
 3. System refrigerant charging shall be witnessed by system manufacturer's representative.
 4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.
- F. Products will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.18 STARTUP SERVICE

- A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
 - 1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
 - 2. Complete startup service of each separate system.
 - 3. Complete system startup service according to manufacturer's written instructions.
- B. Startup checks shall include, but not be limited to, the following:
 - 1. Check control communications of equipment and each operating component in system(s).
 - 2. Check each indoor unit's response to demand for cooling and heating.
 - 3. Check each indoor unit's response to changes in airflow settings.
 - 4. Check each indoor unit and outdoor unit for proper condensate removal.
 - 5. Check sound levels of each indoor and outdoor unit.
- C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.
 - 1. Installer shall correct deficiencies found during startup service for reverification.
- D. System Operation Report:
 - 1. After completion of startup service, manufacturer shall issue a report for each separate system.
 - 2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
 - 3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.
 - a. All available system operating parameters shall be included in the information submitted.
- E. Witness:
 - 1. Invite Architect, Owner and Commissioning Agent to witness startup service procedures.
 - 2. Provide written notice not less than 20 business days before start of startup service.

3.19 ADJUSTING

- A. Adjust equipment and components to function smoothly and lubricate as recommended by manufacturer.
- B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

- D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.20 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
- C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.21 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system. Include two service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.22 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.23 DEMONSTRATION

- A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
- B. Instructor:
 - 1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.

2. Instructor's credentials shall be submitted for review by Architect and Owner before scheduling training.
 3. Instructor(s) primary job responsibility shall be Owner training.
 4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.
- C. Schedule and Duration:
1. Schedule training with Owner at least 20 business days before first training session.
 2. Training shall occur before Owner occupancy.
 3. Training shall be held at mutually agreed date and time during normal business hours.
 4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
 5. Perform not less than eight total hours of training.
- D. Location: Owner shall provide a suitable on-site location to host classroom training.
- E. Training Attendees: Assume three people.
- F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
- G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.
- H. Training Materials: Provide training materials in electronic format to each attendee.
1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- I. Acceptance: Obtain Architect or Owner written acceptance that training is complete and requirements indicated have been satisfied.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 238129

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Building wire and connectors.
2. Electricity metering components.
3. Sleeves for electrical penetrations.
4. Cutting and patching for electrical construction.
5. Accessories required for a complete installation.
6. Training requirements.

- B. Requirements of this section apply to all sections in Division 26 and other sections that include electrical work.

1.2 DEFINITIONS

A. Product Types:

1. EMT: Electrical metal tubing, ANSI C80.3.
2. FMC: Flexible metallic conduit.
3. LFMC: Liquidtight flexible metal conduit.
4. RMC: Rigid metallic conduit.
5. RNC: Rigid nonmetallic conduit, NEMA PC-2.

1.3 SUBMITTALS

- A. Shop Drawings: Dimensioned plans and sections or elevation layouts and single line diagram of electrical component assemblies.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings for electrical supports, raceways, and cable with general construction work. Provide coordination drawings for approval to show all penetrations.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment that requires positioning and mounting.
- C. Coordinate electrical service connections to components furnished by utility companies.
- D. Coordinate installation and connection of exterior underground electrical, including provision for service electricity metering components.
- E. Coordinate location of access panels and doors for electrical items concealed by finished surfaces.
- F. Where electrical identification devices are applied to field finished surfaces, coordinate installation of identification devices with completion of finished surface.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeve: ASTM A53 Type E, Grade B, Schedule 40, galvanized steel, plain ends.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom.
- D. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- F. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 APPLICATIONS

A. Raceways:

1. Outdoor Installations:

- a. Exposed: RMC.
- b. Concealed: RMC.
- c. Underground, Single Run: Concrete encased RNC without reinforcement as indicated on Drawings.
- d. Underground, Grouped: Concrete encased RNC with reinforcement as indicated on Drawings.
- e. Connection to Vibrating Equipment: LFMC.
- f. Boxes and Enclosures: NEMA 250, Type 3R or Type 4X, unless otherwise indicated.

2. Indoor Installations:

- a. Exposed: EMT.
- b. Concealed in Walls or Ceilings: EMT.
- c. In Concrete Slab: RNC.
- d. Below Slab on Grade or in Crawlspace: RNC.
- e. Connection to Vibrating Equipment: FMC; except in wet or damp locations: LFMC.
- f. Boxes and Enclosures: NEMA 250, Type 1, unless otherwise indicated.

3.3 RACEWAY AND CABLE INSTALLATION

- A. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.
- B. Keep legs of raceway bends in the same plane and keep straight legs of offsets parallel.
- C. Use RMC elbows where RNC turns out of slab.
- D. Install pull wires in empty raceways. Use woven polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inches of slack at each end of pull wires.
- E. Connect motors and equipment subject to vibration, noise transmission, or movement with a maximum of 72-inches flexible conduit. Install LFMC in wet or damp locations. Install separate ground conductor across flexible connections.

3.4 WIRING METHODS FOR POWER, LIGHTING, AND CONTROL CIRCUITS

- A. Use wiring methods specified below to the extent permitted by applicable codes as interpreted by authorities having jurisdiction.
- B. Exposed Feeders: Insulated single conductors in raceway.

- C. Concealed Feeders in Ceilings, Walls, Gypsum Board Partitions: Insulated single conductors in raceway. MC cable may be accepted if submitted for approval.
- D. Concealed Feeders in Concrete, Below Floors on Grade: Insulated single conductors in raceway.
- E. Exposed Branch Circuits: Insulated single conductors in raceway.
- F. Concealed Branch Circuits in Ceilings, Walls and Gypsum Board Partitions: Insulated single conductors in raceway. MC cable may be accepted if submitted for approval.
- G. Concealed Branch Circuits in Concrete, below Floors on Grade: Insulated single conductors in raceway.
- H. Underground Feeders and Branch Circuits: Insulated single conductors in raceway.
- I. Remote Control Signaling and Power-Limited Circuits, Classes 1, 2, and 3: Insulated conductors in raceway.

3.5 WIRING INSTALLATION

- A. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

3.6 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves where electrical raceways, cables, wireways, cable trays, or busways penetrate concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- D. Cut sleeves to length for mounting flush with both surfaces of walls.
- E. Extend sleeves installed in floors 2 inches above finished floor level.
- F. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- G. Seal space outside of sleeves with grout for penetrations of concrete or masonry.
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Where sleeves are indicated, seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements of Section 07 90 00, Joint Protection.

- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials.
- J. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

3.7 FIRESTOPPING

- A. Apply firestopping to cable and raceway sleeves and other penetrations of fire rated floor and wall assemblies to restore original undisturbed fire resistance ratings of assemblies.

3.8 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair, refinish, and touch up disturbed finish materials and other surfaces to match adjacent undisturbed surfaces.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 05 00

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SECTION 26 05 19 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.
2. Accessories required for a complete installation.

1.2 SUBMITTALS

- A. Field quality control test reports.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified, or equal approved as a substitution:

1. Conductors and Cables:

- a. Alcan Products Corporation, Alcan Cable div.
- b. American Insulated Wire Corp., a Leviton Company.
- c. General Cable Technologies Corp.
- d. Southwire Company.

2. Connectors and Splices:

- a. AFC Cable Systems, Inc., div. Tyco Electrical and Metal Products.
- b. AMP brand, Tyco Electronics.
- c. Anderson Electrical Products, Inc., subsidiary Hubbell Incorporated.

- d. O-Z/Gedney brand, EGS Electrical Group.
 - e. 3M Company, Electrical Products Division.
- B. Conductor Material: Copper complying with NEMA WC 70; solid conductor for No. 10 AWG and smaller, stranded for No. 8 AWG and larger.
 - 1. Conductor Insulation Types: Type THHN-THWN indoors, XHHW outdoors complying with NEMA WC 70.
- C. Connectors and Splices: Factory fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR AND INSULATION APPLICATIONS

- A. Exposed Feeders and Branch Circuits: Type THHN-THWN indoors, XHHW outdoors, single conductors in raceway.
- B. Feeders and Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN indoors, XHHW outdoors, single conductors in raceway.
- C. Feeders and Branch Circuits Concealed in Concrete, Below Slabs on Grade, and in Crawlspace: Type THHN-THWN indoors, XHHW outdoors, single conductors in raceway.
- D. Fire Alarm Circuits: Type THHN-THWN, in raceway.
- E. Underground Feeders and Branch Circuits: Type XHHW in raceways.

3.2 INSTALLATION

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Use manufacturer approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables in accordance with requirements.
- F. Seal around cables penetrating fire rated elements.

- G. Identify and color code conductors and cables according to Section 26 05 53, Identification for Electrical Systems.
- H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- I. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.3 FIELD QUALITY CONTROL

- A. Testing: Perform each electrical test and visual and mechanical inspection stated in NETA ATS (Acceptance Testing Specifications), Section 7.3.1. Certify compliance with test parameters.
- B. Test Reports: Prepare a written report to record:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 260519

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SECTION 26 05 24 – WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single and duplex receptacles, ground fault circuit interrupters.
2. Single pole snap switches.
3. Device wall plates.
4. Accessories required for a complete installation.

1.2 SUBMITTALS

- A. Product Data: Technical data for each type of product indicated.
- B. Field quality control test reports.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Products.

2.2 MATERIALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or equal approved as a substitution:
 1. Wiring Devices:
 - a. Bryant Electric, div. Hubbell Inc.

- b. Cooper Wiring Devices.
 - c. Hubbell Wiring Device-Kellems, div. Hubbell Incorporated.
 - d. Leviton Mfg. Company Inc.
 - e. Pass & Seymour/Legrand.
- 2. Multioutlet Assemblies:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. Wiremold / Legrand.
- B. Receptacles:
 - 1. Straight Blade Type Receptacles: Comply with NEMA WD 1, NEMA/ANSI WD 6, DSCC W-C-596G, and UL 498.
 - 2. Straight Blade and Locking Receptacles: Heavy-Duty grade.
 - 3. GFCI Receptacles: Straight blade, nonfeed through type, with integral NEMA/ANSI WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4 inch deep outlet box without an adapter.
- C. Switches:
 - 1. Single and Double Pole Switches: Comply with DSCC W-S-896F and UL 20.
 - 2. Snap Switches: Heavy Duty grade, quiet type.
- D. Wall Plates: Single and combination types to match corresponding wiring devices.
 - 1. Plate Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: Stainless steel.
 - 3. Material for Unfinished Spaces: Stainless steel.
 - 4. Material for Wet Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet locations.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install devices and assemblies level, plumb, and square with building lines.
- B. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- C. Remove wall plates and protect devices and assemblies during painting.

3.2 IDENTIFICATION

- A. Comply with Section 26 05 53, Identification for Electrical Systems.

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 CONNECTIONS

- A. Ground equipment according to Section 26 05 26, Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 05 19, Low Voltage Electrical Power Conductors and Cables.

3.4 FIELD QUALITY CONTROL

- A. Perform field tests and inspections and prepare test reports:
 1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
 2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- B. Remove malfunctioning units, replace with new units, and retest as specified above.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 260524

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SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding of electrical systems and equipment.
2. Accessories required for a complete installation.

1.2 SUBMITTALS

- A. Product Data: Technical data for ground rods and grounding conductors.
- B. Reports: Field quality control test reports.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled under UL 467 as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Products.

2.2 COMPONENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or equal approved as a comparable product:
 1. A. B. Chance, subsidiary of Hubbell Power Systems.
 2. Dofasco Tubular Products.
 3. Ideal Industries, Inc.
 4. ILSCO.
 5. Kearney brand, Cooper Power Systems.
 6. Raco brand, Hubbell Power Systems.

B. Grounding Conductors:

1. For insulated conductors, comply with Section 26 05 19, Low Voltage Electrical Power Conductors and Cables.
2. Equipment Grounding Conductors: Insulated with green colored insulation.
3. Bare, Solid Copper Conductors: ASTM B3.
4. Assembly of Bare, Stranded-Copper Conductors: ASTM B8.
5. Copper Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
6. Copper Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Copper Bonding Jumper: Tinned copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
8. Connectors: Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items. Use compression type where exposed and exothermic-welded type, in kit form, selected per manufacturer's written instructions where concealed or buried in earth

C. Grounding Electrodes: Ground rods, copper clad steel; size: 3/4 inch in diameter by 120 inches long.**PART 3 - EXECUTION****3.1 INSTALLATION**

- A. Use copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermic Welded Connections: Use for connections to structural steel and for underground connections.
- D. Underground Grounding Conductors: Use copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches below grade or bury directly below duct bank when installed as part of the duct bank.
- E. Equipment Grounding Conductors: Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
 1. Install insulated equipment grounding conductors in all feeders and branch circuits.
 2. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
- F. Metal Frame Grounding for Generator: Provide grounding as shown on drawings.
- G. Ground Rods: Drive ground rods until tops are 12 inches below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except as otherwise indicated. Make connections without exposing steel or damaging copper coating.
- H. Grounding Conductors: Route along shortest and straightest paths possible. Avoid obstructing access or placing conductors where subjected to strain, impact, or damage.
- I. Bonding Straps and Jumpers: Install so that vibration by equipment mounted on vibration isolation hangers or supports is not transmitted to rigidly mounted equipment. Use exothermic welded connectors for outdoor locations, unless disconnect type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
- J. Connections: Make connections so that galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so that metals in direct contact will be galvanically compatible.
 1. Use electroplated or hot tin coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum to steel connections with stainless steel separators and mechanical clamps.
 4. Make aluminum to galvanized steel connections with tin plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
 6. Exothermic Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
 7. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure type connectors.
 8. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
 9. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
 10. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 260526

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. RMC: Rigid metal conduit.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.4 SUBMITTALS

- A. Product Data: For the following:
 1. Steel slotted support systems.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1 (D1.1M), Structural Welding Code—Steel.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Products.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
1. Manufacturers: Subject to compliance with requirements, provide products of the following manufacturers, or equal approved as a comparable product:
 - a. Allied Tube & Conduit, div. Tyco Electrical and Metal Products.
 - b. Cooper B-Line, Inc., div. Cooper Industries.
 - c. Erico International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut, div. Tyco Electrical and Metal Products.
 - g. Wesanco, Inc.
 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 3. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101. Including manufactured clevis hangers, riser clamps, straps, threaded C clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps or click type hangers.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A36, steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products of the following, or equal approved as a comparable product:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head, div. Illinois Tool Works, Inc.
 - 3) MKT Fastening.
 - 4) Simpson Strong-Tie Co., Inc.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for

supported loads and building materials in which used.

- a. Manufacturers: Subject to compliance with requirements, provide products of the following, or equal approved as a comparable product:
 - 1) Cooper B-Line, Inc., div. Cooper Industries.
 - 2) Hilti, Inc.
 - 3) ITW Ramset/Red Head, div. Illinois Tool Works, Inc.
 - 4) MKT Fastening.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with single-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten

electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 6. To Steel: Welded threaded studs complying with AWS D1.1, with lock washers and nuts, or beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03.
- C. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
- D. Touchup: Comply with requirements in Section 09 91 00, Painting, for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- E. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 05 29

SECTION 26 05 33 – RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.2 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. RMC: Rigid metal conduit.
- D. LFMC: Liquidtight flexible metal conduit.
- E. RNC: Rigid nonmetallic conduit.

1.3 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: Show fabrication and installation details of components for raceways, fittings, boxes, enclosures, and cabinets.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Products.

2.2 METAL CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products of one of the following, or equal approved as a comparable product:
1. AFC Cable Systems, Inc., div. Tyco Electrical and Metal Products.
 2. Anaconda Sealtite brand, Anamet Electrical Inc.
 3. Electri-Flex Co.
 4. Allied Tube and Conduit, div. Tyco Electrical and Metal Products.
 5. O-Z/Gedney, div. EGS Electrical Group.
 6. Wheatland Tube Co., div. Carlyle Group.
- B. Rigid Steel Conduit: NEMA/ANSI C80.1.
- C. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.
- D. EMT and Fittings: NEMA/ANSI C80.3.
1. Fittings: Compression type.
- E. FMC: Zinc-coated steel.
- F. LFMC: Flexible steel conduit with PVC jacket.
- G. Fittings: NEMA/ANSI FB 1; compatible with conduit and tubing materials.

2.3 NONMETALLIC CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products of one of the following, or equal approved as a comparable product:
1. Anaconda Sealtite brand, Anamet Electrical Inc.
 2. Arnco Corp.
 3. Cantex Inc.
 4. CertainTeed Corp., Pipe & Plastics Group.
 5. Condux International.
 6. Elecsys Corporation.
 7. Electri-Flex Co.
 8. Carlon brand, Lamson & Sessions.
 9. RACO brand, Hubbell Inc.
 10. AFC Cable Systems, div. Tyco Electrical and Metal Products.

- 11. Thomas & Betts Corporation.
- B. ENT: NEMA TC 13.
- C. RNC: NEMA TC 2, Schedule 40 and Schedule 80 PVC.
- D. ENT and RNC Fittings: NEMA TC 3; match to conduit or tubing type and material.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products of one of the following, or equal approved as a comparable product:
 - 1. Cooper Crouse-Hinds, div. of Cooper Industries, Inc.
 - 2. Appleton Electric, brand of EGS Electrical Group, joint venture of Emerson and SPX Corporation.
 - 3. Erickson Electrical Equipment Co.
 - 4. Hoffman Enclosures, div. CHS Controls AB.
 - 5. Killark brand, Hubbell Inc.
 - 6. O-Z/Gedney, div. EGS Electrical Group.
 - 7. RACO brand, Hubbell Inc.
 - 8. Robroy Industries.
 - 9. Adalet Enclosure Systems, div. Scott Fetzer Co.
 - 10. Spring City Electrical Manufacturing Co.
 - 11. Thomas & Betts Corporation.
 - 12. Wiremold / Legrand.
 - 13. Daniel Woodhead brand, Woodhead Industries, div. Molex Inc.
- B. Sheet Metal Outlet and Device Boxes: NEMA/ANSI OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA/ANSI FB 1, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: NEMA/ANSI OS 2.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA/ANSI OS 1.
- F. Cast-Metal Pull and Junction Boxes: NEMA/ANSI FB 1, cast aluminum with gasketed cover.
- G. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.
- H. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

2.5 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard gray paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors:

1. Exposed: Rigid steel.
2. Concealed: Rigid steel.
3. Underground, Single Run: Concrete encased RNC without reinforcement.
4. Underground, Grouped: Concrete encased RNC.
5. Boxes and Enclosures: NEMA 250, Type 3R.

B. Indoors:

1. Exposed: Rigid steel.
2. Concealed: Rigid steel.
3. Damp or Wet Locations: Rigid steel conduit.
4. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
 - a. Damp or Wet Locations: NEMA 250, Type 4, nonmetallic unless otherwise noted.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz.

F. Do not install aluminum conduits embedded in or in contact with concrete.

3.2 INSTALLATION

- A. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- B. Complete raceway installation before starting conductor installation.
- C. Support raceways as specified in Section 26 05 00, Common Work Results for Electrical.
- D. Install temporary closures to prevent foreign matter from entering raceways.

- E. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so that curved portions of bends are not visible above the finished slab.
- F. Make bends and offsets so that ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- G. Conceal conduit within finished walls, ceilings, and floors, unless otherwise indicated.
 - 1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
- H. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
 - 1. Run parallel or banked raceways together on common supports.
- I. Join raceways with fittings designed and approved for that purpose and make joints wrench tight.
 - 1. Use insulating bushings to protect conductors.
- J. Terminations:
 - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
 - 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so that end bears against wire protection shoulder. Where chase nipples are used, align raceways so that coupling is square to box; tighten chase nipple so that no threads are exposed.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- L. Provide expansion fittings in conduit runs as required in the NEC where necessary to compensate for thermal expansion and contraction.
- M. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- N. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.
- O. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.

3.3 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.4 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 05 33

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Electrical identification.

1.2 SUBMITTALS

- A. Product Data: Submit data for each electrical identification product.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with NFPA 70.

1.4 COORDINATION

- A. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- B. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION

- A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by ASME A13.1, NFPA 70, and these Specifications.
- B. Raceway and Cable Labels: Comply with ASME A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway and cable size.
 - 1. Type: Pretensioned, wraparound plastic sleeves. Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the item identified.
 - 2. Type: Preprinted, flexible, self-adhesive, vinyl. Legend is overlaminated with a clear, weather- and chemical-resistant coating.
 - 3. Color: Black letters on orange background.
 - 4. Legend: Indicates voltage.
 - 5. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 1 inch wide by 3 mils thick.

- C. Underground Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape with the following features:
 - 1. Minimum 6 inches wide by 4 mils thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend that indicates type of underground line.
- D. Tape Markers for Wire: Vinyl or vinyl cloth, self adhesive, wraparound type with preprinted numbers and letters.
 - 1. Color Coding Cable Ties: Type 6/6 nylon, self locking type. Colors to suit coding scheme.
- E. Engraved Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1/16-inch minimum thickness for signs up to 20 square inches and 1/8 inch minimum thickness for larger sizes. Engraved legend in black letters on white background.
- F. Interior Warning and Caution Signs: Comply with 29 CFR 1910.145. Preprinted, aluminum, baked enamel finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.
- G. Exterior Warning and Caution Signs: Comply with 29 CFR 1910.145. Weather resistant, nonfading, preprinted, cellulose acetate butyrate signs with 0.0396 inch galvanized steel backing, with colors, legend, and size appropriate to the application. 1/4 inch grommets in corners for mounting.
- H. Fasteners for Nameplates and Signs: Self tapping, stainless steel screws or No. 10/32 stainless steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 IDENTIFICATION INSTALLATION

- A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the contract documents or required by codes and standards. Use consistent designations throughout project.
- C. Self Adhesive Identification Products: Clean surfaces before applying.
- D. Identify raceways and cables with color banding.
- E. Bands: Pretensioned, snap around, colored plastic sleeves or colored adhesive marking tape. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two color markings in contact, side by side.

1. Band Locations: At changes in direction, at penetrations of walls and floors, at 20 foot maximum intervals in straight runs, and at 10-foot maximum intervals in congested areas. These intervals are to comply with Spotsylvania County Fire Department requirements.
 2. Colors:
 - a. Fire Alarm System: Red.
- F. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color coding may be used for voltage and phase identification.
- G. Install continuous underground plastic markers directly above power and communication lines during trench backfilling, for exterior underground power, control, signal, and communication lines. Locate 6 to 8 inches below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall width, use a single line marker.
- H. Install warning, caution, and instruction signs where required to comply with 29 CFR 1910.145, and where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal backed butyrate signs for outdoor items.
- I. Install engraved laminated emergency operating signs with white letters on red background with minimum 3/8 inch high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 05 53

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SECTION 26 24 16 – PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Branch circuit panelboards.
2. Accessories required for a complete installation.

1.2 SUBMITTALS

A. Product Data: Manufacturer's technical data for each type of panelboard, overcurrent protective device, accessory, and component indicated. Include dimensions and technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard:

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following data:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, and current, and voltage ratings.
 - c. Short circuit current rating of panelboards and overcurrent protective devices.
 - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
2. Wiring Diagrams: Power, signal, and control wiring.

C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

D. Field quality control test reports.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA PB 1.
3. Comply with NFPA 70.

PRODUCTS

1.4 MATERIALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or equal approved as a comparable product:

1. ABB Group.
2. Cutler-Hammer brand, Eaton Corporation.
3. General Electric Company.
4. Siemens Energy & Automation, Inc.
5. Square D brand, Schneider Electric.
6. Or approved equal.

- B. Components:

1. Enclosures: Surface mounted cabinets. NEMA PB 1, Type 1, suitable for environmental conditions at installed location.
 - a. Indoor Locations: NEMA type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Wet or Damp Indoor Locations: NEMA 250, Type 4.
2. Front: Secured to box with concealed trim clamps. For surface mounted fronts, match box dimensions; for flush mounted fronts, overlap box.
3. Finish: Enamel finish over corrosion resistant treatment or primer coat.
4. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.
5. Bus: Hard drawn copper, 98 percent conductivity.
6. Surge protective device: Provide internal surge protection device for each panelboard. See specification section 264300.
7. Equipment Ground Bus: Adequate for feeder and branch circuit equipment ground conductors; bonded to box.
8. Panelboard Short Circuit Rating: As required by available fault current.
9. Fully rated to interrupt symmetrical short circuit current available at terminals, as indicated on drawings. All devices shall be fully rated for the available fault current, no series ratings will be allowed.
10. Spaces for Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
11. Skirt for Surface Mounted Panelboards: Same thickness and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

- C. Lighting and Appliance Branch Circuit Panelboards:

1. Branch Overcurrent Protective Devices: Bolt on circuit breakers, replaceable without disturbing adjacent units.
2. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

- D. Overcurrent Protective Devices:

PANELBOARDS

1. Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents without use of fuses.
 - a. Thermal Magnetic Circuit Breakers: Inverse time current element for low level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit breaker frame sizes 250 A and larger.
 - b. GFCI Circuit Breakers: Single and two pole configurations with 5-mA trip sensitivity.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air conditioning, and refrigerating equipment.

PART 2 - EXECUTION

2.1 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1. Install flush unless otherwise indicated.
- B. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.
- C. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- D. Install filler plates in unused protective device spaces.
- E. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

2.2 IDENTIFICATION

- A. Identify field installed conductors, interconnecting wiring, and components; provide warning signs as specified.
- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated plastic nameplate mounted with corrosion resistant screws.
- C. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

2.3 FIELD QUALITY CONTROL

- A. Testing and Inspection: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 1. Procedures: Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Section 7.6 for molded case circuit breakers.

2. Test insulation resistance of panelboard bus with a megohmmeter, and ground continuity of cabinet and ground bus. Reject buses with insulation resistance less than 2 megohms.
 3. Correct defective and malfunctioning units on site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- B. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24 hour services such as fax machines and on line data-processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 24 16

SECTION 26 28 16 – ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Individually mounted enclosed switches and circuit breakers, rated 600 V and less, used for disconnecting and protection functions.
2. Accessories required for a complete installation.

1.2 SUBMITTALS

- A. Product Data: Technical data for each type of switch and circuit breaker indicated.
- B. Field quality control test reports.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

- B. Source Limitations: Obtain switches and circuit breakers through one source from a single manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Products.

2.2 MATERIALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or equal approved as a comparable product:
 1. ABB Group.

2. Cutler Hammer brand, Eaton Corporation.
3. GE, Electrical Distribution div.
4. Siemens Energy & Automation, Inc.
5. Square D brand, Schneider Electric.

B. Enclosed Switches:

1. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle, interlocked with cover.
2. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, and lockable handle, interlocked with cover.

C. Enclosed Circuit Breakers:

1. Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 - a. Thermal Magnetic Circuit Breakers: Inverse time current element for low level overloads, and instantaneous magnetic trip element for short circuits.
 - b. Current Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - c. GFCI Circuit Breakers: Single and two pole configurations with 5-mA trip sensitivity.
2. Molded Case Circuit Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
 - a. Lugs: Suitable for number, size, trip ratings, and material of conductors.
 - b. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air conditioning, and refrigerating equipment.
 - c. Ground Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time delay settings, push to test feature, and ground-fault indicator.

D. Enclosures:

1. Listed for environmental conditions of installed locations, including:
 - a. Outdoor Locations: NEMA 250, Type 3R.
 - b. Wet or Damp Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Temporary Provisions: Remove temporary lifting provisions and blocking of moving parts.
- B. Identify components; provide warning signs as specified in Section 26 05 53, Identification for Electrical Systems.

3.2 FIELD QUALITY CONTROL

- A. Testing: After installing disconnect switches and circuit breakers and after electrical circuits have been energized, demonstrate product capability and compliance with requirements.
- B. Inspections and Tests for Switches and Circuit Breakers: Make internal and external inspections and perform tests, including the following:
 - 1. Inspect for freedom from physical damage, proper unit rating, mechanical condition, enclosure integrity, cover operation, unit anchorage, clearances, and tightness of electrical connections. If a loose electrical connection is observed on any unit, check each electrical connection for each switch and circuit breaker with a torque wrench for compliance with manufacturer's torquing instructions.
 - 2. Test insulation resistance of each pole, phase to phase, and phase to ground, following manufacturer's written instructions. Test insulation resistance of shunt trip circuits. Use 500-V minimum test voltage for units and circuits rated up to 250 V, 1000-V minimum test voltage for units rated more than 250 V. Measured insulation resistance must be 25 megohms, minimum, for switches rated up to 250 V, and 100 megohms, minimum, for switches rated more than 250 V.
 - 3. Test cover and other interlocks and interlock release devices for proper operation.
- C. Additional Inspections and Tests for Switches: Include the following:
 - 1. Inspect for proper rating and fuse provisions.
 - 2. Check adequacy and integrity of fuseholders by removing and installing fuses.
 - 3. Check integrity of phase barriers.
 - 4. Inspect blade alignment visually while operating switch to observe adequacy of blade pressure.
- D. Additional Inspections and Tests for Circuit Breakers:
 - 1. Inspect for proper frame, trip, and fault current interrupting rating.
 - 2. Test shunt trip devices, circuits, and actuating components for proper operation.
- E. Correct defective and malfunctioning units on site, where possible, and reinspect and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 28 16

SECTION 26 32 13 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes packaged engine-generator sets for stand-by power supply with the following features:
 - 1. Natural gas engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Outdoor weatherproof enclosure.

1.2 ACTION SUBMITTALS

- A. Product Data: For packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
 - 1. Certified summary of prototype-unit test report.
 - 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 - 3. Report of sound generation.
 - 4. Report of exhaust emissions showing compliance with applicable regulations.
- B. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. Include the following:
 - 1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
 - 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with ASME B15.1.
- F. Comply with NFPA 37.
- G. Comply with NFPA 70.
- H. Comply with NFPA 99.
- I. Comply with UL 2200.
- J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- K. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.7 PROJECT CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 40 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators.

1.9 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

1.10 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

1. MTU.
2. Onan/Cummins.
3. Caterpillar.
4. Kohler.
5. Substitutions – or approved equal.

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.

- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated on the drawings.
 - 2. Output Connections: 480/277, three-phase, four wire.
 - 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
 - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 - 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 - 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 - 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 - 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
 - 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 - 7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
 - 8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

- A. Fuel: Natural gas.
- B. Lubrication System: The following items are mounted on engine or skid:
 - 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 - 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- C. Engine Fuel System:
 1. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- D. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 2 equipment for heater capacity.
- E. Governor: Adjustable isochronous, stable at a frequency differential of not more than +/- .25% from 60 Hz, with speed sensing.
- F. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- G. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 1. Minimum sound attenuation of 25 dB at 500 Hz.
 2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.
- H. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- I. Starting System: 24-V electric, with negative ground.
 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

2.4 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- D. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 2 system, and the following:
 1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. Engine-coolant temperature gage.
 6. Engine lubricating-oil pressure gage.
 7. Running-time meter.
 8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
 10. Fuel tank derangement alarm.
 11. Fuel tank high-level shutdown of fuel supply alarm.
 12. Generator overload.

- E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- F. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
 - 1. Overcrank shutdown.
 - 2. Coolant low-temperature alarm.
 - 3. Control switch not in auto position.
 - 4. Battery-charger malfunction alarm.
 - 5. Battery low-voltage alarm.
- G. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.5 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
 - 1. Tripping Characteristic: Designed specifically for generator protection.
 - 2. Trip Rating: Matched to generator rating.
 - 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 - 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.6 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.

- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.7 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
- B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
 - 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
 - 2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

2.8 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - 1. Material: Standard neoprene.
 - 2. Durometer Rating: 30.
 - 3. Number of Layers: One.

2.9 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.10 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.
 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints.
- D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine-generator set with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Coordinate tests with tests for transfer switches and run them concurrently.
- C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Remove and replace malfunctioning units and retest as specified above.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 32 13

SECTION 26 36 00 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes utility to generator transfer switches rated 600 V and less, 3 pole as indicated on the drawings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. Include the following:
 - 1. Features and operating sequences, both automatic and manual.
 - 2. List of all factory settings of relays; provide relay-setting and calibration instructions.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA ICS 1.
- D. Comply with NFPA 70.
- E. Comply with NFPA 99.
- F. Comply with NFPA 110.

- G. Comply with UL 1008 unless requirements of these Specifications are stricter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
1. GE Zenith.
 2. Cutler Hammer.
 3. ASCO.
 4. Or approved equal.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Switch Action: Double throw; mechanically held in both directions.
 2. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- H. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Section 260553 "Identification for Electrical Systems."
1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.

2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- I. Enclosures: General-purpose NEMA 250, Type 3R, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- D. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- E. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- F. Automatic Transfer-Switch Features:
1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 5. Test Switch: Simulate normal-source failure.
 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

- b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
- 8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
- 9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
- 10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
- 11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
- 12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.

2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Identify components according to Section 260553 "Identification for Electrical Systems."
- B. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Coordinate tests with tests of generator and run them concurrently.
- C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
- B. Coordinate this training with that for generator equipment.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 36 00

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SECTION 26 43 00 – TRANSIENT VOLTAGE SUPPRESSION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Transient voltage surge suppressors for low-voltage power, control, and communication equipment.

1.2 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.

C. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated. Other manufacturers' products complying with requirements may be considered. Refer to Section 01 60 00, Products.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. IEEE Compliance: Comply with IEEE C62.41, IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits, and test devices according to IEEE C62.45, IEEE Guide for Surge Suppressor Testing.

F. NEMA Compliance: Comply with NEMA LS 1, Low Voltage Surge Protective Devices.

G. UL Compliance: Comply with UL 1283, Electromagnetic Interference Filters, and UL 1449, Transient Voltage Surge Suppressors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

- B. Product Certificates: Signed by manufacturers of transient voltage suppression devices, certifying that products furnished comply with the following testing and labeling requirements:
 - 1. UL 1283 certification.
 - 2. UL 1449 listing and classification.
- C. Field Test Reports: Written reports of tests specified in Part 3 of this section. Include the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.
- D. Maintenance Data: For transient voltage suppression devices to include in maintenance manuals specified in Division 01.

1.4 PROJECT CONDITIONS

- A. Placing into Service: Do not energize or connect panelboards, control terminals or data terminals to their sources until the surge protective devices are installed and connected.
- B. Service Conditions: Rate surge protective devices for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F .
 - 3. Humidity: 0 to 85 percent, noncondensing.
 - 4. Altitude: Less than 20,000 feet above sea level.

1.5 COORDINATION

- A. Coordinate location of field-mounted surge suppressors to allow adequate clearances for maintenance.

1.6 WARRANTY

- A. General Warranty: Special warranties specified in this Article shall not deprive VRE of other rights VRE may have under other provisions of the contract documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the contract documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of surge suppressors that fail in materials or workmanship within five years from date of Substantial Completion.
- C. Special Warranty for Plug-in Cord-Connected Surge Suppressors: Written warranty, executed

by manufacturer agreeing to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products and manufacturers are listed, make submittals for proposed comparable products and substitutions in accordance with Section 01 60 00, Product Requirements, and Section 01 25 00, Substitution Procedures.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or equal approved as a comparable product:

1. Manufacturers of a Broad Line of Suppressors:

- a. Advanced Protection Technologies, Inc.
- b. Atlantic Scientific Corp.
- c. Current Technology, brand of Danaher Power Solutions, subsidiary of Danaher Corp.
- d. Cutler-Hammer brand, Eaton Electrical Inc.
- e. Innovative Technology brand, Eaton Electrical Inc.
- f. Intermatic, Inc.
- g. LEA International, a Smiths Group company.
- h. Leviton Manufacturing Co. Inc.
- i. Liebert Corp., an Emerson Network Power company, div Emerson.
- j. Northern Technologies Corp.
- k. Siemens Energy & Automation.
- l. Square D, brand of Schneider Electric.
- m. Transtector Systems, Inc., a Smiths Group company.
- n. Zero Surge Inc.

2. Manufacturers of Category A and Low voltage Line Suppressors:

- a. MCG Surge Protection.
- b. Telebyte, Inc.

2.3 PANELBOARD SUPPRESSORS

- A. Surge Protective Device Description: Non-modular type with the following features and accessories:
1. LED indicator lights for power and protection status.
 2. Audible alarm, with silencing switch, to indicate when protection has failed.
 3. One set of dry contacts rated at 5 A, 250-V AC, for remote monitoring of protection status.
- B. Surge Protective Device Description: Modular design with field-replaceable modules and the following features and accessories:
1. Fuses, rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 7. Red and green LED indicator lights for power and protection status.
 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 9. One set of dry contacts rated at 5 A, 250-V, AC, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 10. Surge-event operations counter.
- C. Peak Single-Impulse Surge Current Rating: 120 kA per phase.
- D. Protection modes and UL 1449 clamping voltage for 240/120 V, single-phase, 3-wire circuits, shall be as follows:
1. Line to Neutral: 400 V.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.
- E. Protection modes and UL 1449 clamping voltage for 240/120 V, 3-phase, 4-wire circuits, with high leg shall be as follows:
1. Line to Neutral: 400 V, 800 V from high leg.
 2. Line to Ground: 400 V.
 3. Neutral to Ground: 400 V.

2.4 CONTROL AND DATA TERMINALS

- A. Protectors for copper control and data conductors entering the building from the outside shall be as recommended by the manufacturer for the type of line being protected.

2.5 ENCLOSURES

- A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTIVE DEVICES

- A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.
- B. Install devices for panelboard and auxiliary panels with conductors between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - 1. Provide multipole, 15-A circuit breaker as a dedicated disconnect for the suppressor, unless otherwise indicated.

3.2 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Testing: Contractor shall engage an independent qualified testing agency to perform the following field quality-control testing:
 - 1. After installing surge protective devices, but before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Complete startup checks according to manufacturer's written instructions.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.19. Certify compliance with test parameters.
 - 4. Submit a written report of the test results per the requirements of 1.2C, Field Test Reports, and compliance certifications.
- B. Repair or replace malfunctioning units. Retest after repairs or replacements are made.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
 - 1. Verify that electrical wiring installation complies with manufacturer's installation requirements.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train VRE's maintenance personnel to adjust, operate, and maintain surge protective devices.

1. Train VRE's maintenance personnel on procedures and schedules for maintaining suppressors.
2. Review data in maintenance manuals. Refer to Section 01 78 00, Closeout Submittals.
3. Schedule training with VRE, through Engineer, with at least seven days' advance notice.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 43 00

SECTION 26 51 00 –LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. LED Lighting fixtures with lamps and power supplies.
2. LED lighting fixtures mounted on exterior building surfaces.
3. Exit signs.
4. Accessories required for a complete installation.

1.2 SUBMITTALS

- A. Product Data: Technical data for each type of lighting fixture scheduled, arranged in order of fixture designation. Include data on features, accessories, and finishes.
- B. Shop Drawings: Show details of fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
 1. Include wiring diagrams.
- C. Product Certificates: For each type of power supply, signed by product manufacturer.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.
3. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

PART 2 - PRODUCTS

2.1 FIXTURES AND COMPONENTS

- A. Lighting Fixtures: Fixture types indicated on drawings set a level of quality; similar fixtures from other manufacturers will be considered when submitted for review.
- B. Exit Signs: Comply with UL 924; for sign colors and lettering size, comply with authorities having jurisdiction.

1. Internally lighted signs.
2. Lamps for AC Operation: Light emitting diodes, 70,000 hours minimum of rated lamp life.

C. LED Lighting Fixtures:

1. Exterior building-mounted fixtures shall utilize high-efficiency light-emitting diodes (LEDs) mounted to a metal core circuit board and aluminum heat sink, ensuring optimal thermal management.
2. 4000 K temperature; Color Rendering Index (CRI) greater than 70.
3. Electronic drivers shall be accessible through a hinged door. LED drivers shall have power factor greater than 90% and Total Harmonic Distortion (THD) less than 20%.

2.2 FIXTURE SUPPORT COMPONENTS

- A. Comply with Section 26 05 00, Common Work Results for Electrical, for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single Stem Hangers: 1/2 inch.
- C. Twin Stem Hangers: Two, 1/2 inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A641, Class 3, soft temper, zinc coated, 12 gauge.
- E. Wires For Humid Spaces: ASTM A 580, Composition 302 or 304, annealed stainless steel, 12 gauge.
- F. Rod Hangers: 3/16 inch minimum diameter, cadmium plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Suspended Fixture Support:
 1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 2. Stem Mounted, Single Unit Fixtures: Suspend with twin stem hangers.
 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
 4. Continuous Rows: Suspend from cable.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- B. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 26 51 00

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SECTION 28 31 11 – FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 REQUIREMENTS

- A. The latest editions to the following codes and standards shall apply as a minimum but not be all inclusive to the design and installation of fire alarm systems:
 - 1. National Fire Protection Association (NFPA) 101 -Life Safety Code.
 - 2. NFPA 1 National Fire Prevention Code.
 - 3. NFPA 70 - National Electrical Code.
 - 4. NFPA 72 - National Fire Alarm Code.
 - 5. NFPA 130 -Standard for Fixed Guideway Transit and Passenger Rail Systems.
 - 6. ANSI/ASME A17.1 -- Safety Code For Elevators and Escalators as adopted by the local authorities having jurisdiction.
 - 7. Americans with Disabilities Act (ADA).

1.3 SYSTEM DESCRIPTION

- A. Fire alarm and detection systems shall be analog/addressable, non-voiced elevator recall system.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
 - 2. Include voltage drop calculations for notification appliance circuits.
 - 3. Include battery-size calculations.
 - 4. Include performance parameters and installation details for each detector, verifying that each detector is listed for application for which the detector is operating.
 - 5. Include plans, sections, and elevations detectors and access to them. Locate detectors according to manufacturer's written recommendations.
 - 6. Include FACP layout, grounding schematic, and single-line connection diagram.
 - 7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified fire-alarm technician, Level III minimum.
 - c. Licensed or certified by authorities having jurisdiction.

1.5 QUALITY ASSURANCE

- A. The system and all components shall be listed by Underwriters Laboratory (UL) for fire protective signaling service (local and remote station, emergency communication and relocation equipment, and protective signaling systems) under UL864.

1.6 SEQUENCE OF OPERATION

- A. Heat Detector: Activation of any heat detector shall initiate elevator recall mode. When the heat detector latches into the alarm mode the fire alarm system shall automatically operate all audible and visual appliances and produce an alarm signal at the control unit.
- B. Trouble Signals: Loss of primary power, short circuit, open faults, ground faults, missing detectors, abnormal detector status (e.g.: dirty detector, replacement incompatible with the defined address), disabled devices and abnormal control functions shall initiate audible and visible trouble signals at the control unit and remote annunciators. Audible trouble signals shall sound until silenced. Silenced trouble signals shall be continuously indicated by a textual message and a trouble LED until restored to normal operation. The trouble LED shall remain illuminated until all abnormal conditions are cleared. Upon a return to normal operation, the audible trouble signal shall resound until restored to normal position. Subsequent trouble events shall re-sound audible trouble signals until silenced.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
 1. Firelight (Honeywell).
 2. Notifier.
 3. Silent Knight.
 4. Edwards.
 5. Or approved equal.

2.2 CONTROL PANEL

- A. The fire alarm and detection system shall be microprocessor based, power-limited, supervised, 24 VDC, non-coded system. The system shall be capable of providing the following functions:
 - 1. Integral clock/calendar.
 - 2. Three-pulse temporal pattern evacuation signal.
 - 3. Functional walk-test of all initiating and signaling devices.
 - 4. Dial out telephone connection (DACT). (Future)

2.3 SUPERVISION

- A. Style 4 (Class B) supervision of all initiation devices is required. Notification appliance wiring shall also be Style Y (Class B).

2.4 POWER SUPPLY

- A. Primary power shall consist of a two-wire, grounded 120 VAC branch circuit from the emergency power distribution panel. The branch circuit disconnect shall be arranged and protected to prevent inadvertent disconnection and ensure optimum reliability. Standby power consisting of rechargeable batteries shall be provided. Batteries shall be capable of powering the system in the normal (standby) mode for 24 hours followed by 5 minutes of operation in the alarm mode.

2.5 PASSWORDS AND SECURITY

- A. Access to control unit and remote annunciator switches wiring and power supplies shall be restricted by keyed-alike locks. Passwords shall be set to 123456.

2.6 ALARM INITIATING DEVICES

- A. Alarm initiating devices consist of addressable analog detectors connected to the system control unit via Class B circuits.

2.7 HEAT DETECTORS

- A. Addressable Heat detectors shall be plug-in type with base for elevator shaft and elevator equipment room. The detector base shall be of the twist lock type with screw terminals for field wiring. Heat detectors outside of the elevator doors shall be of the conventional rate-anticipation 135 degree F type, weatherproof, corrosion resistant, tamper-proof with addressable monitor modules mounted indoor nearby. Fire-Light 302-ET-135 or approved equal.

2.8 NOTIFICATION APPLIANCES

- A. Alarm notification appliances shall consist of audible and visual signals for public signaling of fire.

- B. General Requirements for Notification Appliances: Connected to notification appliance signal circuits equipped for weatherproof mounting as indicated and with screw terminals for system connections.
 - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
- C. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, weatherproof with clear or nominal white polycarbonate lens mounted on an aluminum faceplate with gasket. The word "FIRE" is engraved in minimum 1-inch high letters on the lens.
 - 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 - 2. Mounting: Wall mounted unless otherwise indicated.
 - 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 - 4. Flashing shall be in a temporal pattern, synchronized with other units.
 - 5. Strobe Leads: Factory connected to screw terminals.
 - 6. Mounting Faceplate: Factory finished, white.
- D. Telephone Connection: Provide components necessary to dial out alarm signals (DACT) - Future.

PART 3 - EXECUTION

3.1 QUALIFICATIONS

- A. System design and installation shall be supervised by an experienced fire alarm technician or fire protection engineer with not less than five years experience with fire alarm systems. Shop drawings shall be prepared and signed by a NICET Level III certified engineering technician or a registered fire protection engineer. The signature of the technician or engineer constitutes an affidavit that the statements, representations, and information presented in the submittal constitute a complete operational system conforming with applicable state codes and recognized engineering practices. All field installation work shall be continuously supervised by a NICET Level II or III fire alarm system technician.

3.2 FIRE ALARM CONTROL PANEL (FACP)

- A. Location: The FACP shall be located as shown on the drawings.
- B. Lockset: The lockset for the FACP shall be keyed for a CAT45 key.
- C. Battery Box: Auxiliary batteries shall be stored in a battery box located adjacent to the FACP. The lockset for the battery box shall be keyed the same as the FACP.

3.3 INITIATING DEVICES

- A. Rate-Anticipation Heat Detectors: Conventional rate-anticipation heat detectors with remote addressable monitor modules shall be installed in accordance with NFPA 72 at the following locations:
 - 1. At elevator exits.
- B. Heat Detectors: Heat detectors shall be provided in accordance with NFPA 72 at the following locations:
 - 1. Mechanical equipment rooms.
 - 2. Elevator shafts.
- C. Interface Modules (Control): Addressable interface modules shall be provided in a controlled environment as close as possible to the device being controlled for the control of the following auxiliary functions:
 - 1. Elevator recall.

3.4 SPARE PARTS

- A. The fire alarm system contractor shall supply a minimum of one replacement for each six devices (or fraction thereof) installed of the following devices:
 - 1. Rate-anticipation heat detectors.
 - 2. Interface Modules (control).
 - 3. Horn/Strobe Signals.
 - 4. Addressable Heat Detectors.
 - 5. Monitor Modules.

3.5 WIRING

All field wiring shall be installed in conduit. Conduit and boxes shall be sized according to National Electrical Code requirements based on the number of conductors. Initiating device circuit wiring shall be fire alarm cable, FPL, #16 AWG copper, 75 deg C, regular capacitance. CommScope twisted with integral shield and ground. Notification appliance circuits shall be fire alarm cable, FPL minimum 14 AWG. Primary power (AC) branch circuit conductors shall be minimum 12 AWG, THWN. Signaling line circuit conductors shall be fire alarm cable, twisted shielded pair FPL, #18 AWG copper, 75 deg C, data grade, low capacitance. CommScope S218SSOR, West Penn #D975, or manufacturer approved equal. All conductors which are terminated, spliced, or otherwise interrupted shall be connected to terminal blocks. Make all connections with pressure type terminal blocks, which are securely mounted. The use of wire nuts or similar devices shall be prohibited.

- 1. Identification: Fire alarm circuits shall be identified by red junction box covers stenciled in white letters "FIRE ALARM."
- 2. All fire alarm system conduit, both exposed and hidden shall be painted red.

3.6 SYSTEM TESTING

- A. All initiating and notification appliances, control equipment, accessories, and auxiliary functions shall be tested in accordance with NFPA 72 acceptance test procedures.

3.7 TRAINING

- A. Provide complete certified factory technical training for a minimum of two selected representatives. The select representatives shall, upon completion of the above training, be factory qualified to perform complete maintenance and repair of the fire alarm system. The contractor shall assume the responsibility to coordinate with the Owner the location and time required for the above certified factory technical training.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 28 31 11

SECTION 284400 - REFRIGERANT DETECTION AND ALARM

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant monitors and notification appliances.

1.2 DEFINITIONS

- A. LCD: Liquid-crystal display.
- B. LED: Light-emitting diode.
- C. PIR: Photoacoustic infrared.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of refrigerant monitor, include refrigerant sensing range in ppm, temperature and humidity range, alarm outputs, display range, furnished specialties, installation requirements, and electric power requirement.
- B. Shop Drawings:
 - 1. Air-Sampling Tubing: Size, routing, and termination including elevation above finished floor.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Include machinery-room layout showing location of monitoring devices and air-sampling tubing with filter/inlet locations in relation to refrigerant equipment.
- B. Product Certificates: For monitoring devices, signed by product manufacturer.
- C. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant monitoring equipment to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. One calibration kit including clean air calibration gas bottle for zero calibration and specific refrigerant calibration gas for span calibration, minimum 58-L capacity, pressure regulator, and tubing.

1.7 COORDINATION

- A. Coordinate refrigerant detection and alarm system with refrigerant contained in refrigeration equipment for compatibility.

PART 2 - PRODUCTS

2.1 PIR REFRIGERANT MONITOR

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. MSA: Chillgard Refrigerant Monitors.
 - 2. Haloguard Monitors
 - 3. Approved equal.
- B. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and automatically activating ventilation system.
- C. Standard: Monitoring system shall comply with ASHRAE 15.
- D. Performance:
 - 1. Refrigerant to Be Monitored R-410A.
 - 2. Range: 0 to 1000 ppm.
 - 3. Sensitivity:
 - a. Accuracy: 0 to 50 ppm; plus or minus 1 ppm. 51 to 1000 ppm; plus or minus 10 percent of reading.
 - b. Repeatability: Plus or minus 1 percent of full scale.
 - c. Response: Maximum 10 seconds per sample.
 - d. Detection Level Set Points:
 - 1) Detection Level 1: 20 ppm.
 - 2) Detection Level 2 : 50 ppm.
 - 3) Detection Level 3: 250 ppm.
 - 4. Sensitivity:

- a. Minimum Detectability: 20 ppm.
 - b. Accuracy: 0 to 100 ppm; plus or minus 20 ppm, 100 to 1000 ppm; plus or minus 5 percent of reading.
 - c. Repeatability: Plus or minus 1 percent of full scale.
 - d. Response: 50 percent of a step change in 60 seconds.
 - e. Detection Level Set Points:
 - 1) Detection Level 1: 20 ppm.
 - 2) Detection Level 2: 50 ppm.
 - 3) Detection Level 3: 250 ppm.
5. Operating Temperature: 32 to 104 deg F.
6. Relative Humidity: 20 to 95 percent, noncondensing over the operating temperature range. Compensate sensor for relative humidity.
- E. Input/Output Features:
- 1. Maximum Power Input: 120-V ac, 60 Hz, 75 W.
 - 2. Number of Air-Sampling Points: One.
 - 3. Air-Sampling Point Inlet Filter: 0.10-micron filter element for each sampling point.
 - 4. Air-Sampling Point Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms matched to sensor output.
 - 5. Alarm Relays: Minimum 4 relays at a minimum of 5-A resistive load each.
 - 6. Alarm Set Points: Displayed and adjustable through keypad on front of meter.
 - 7. Alarm Silence Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.
 - 8. Alarm Manual Reset: Momentary-contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.
 - 9. Display: Alphanumeric LCD, LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault/trouble LEDs.
 - 10. Audible Output: Minimum 75 dB at 10 feet.
 - 11. Visible Output: Strobe light.
 - 12. Sensor Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.
 - 13. Serial Output: RS-232 or RS-485.
 - 14. Enclosure: NEMA 250, Type 1, with locking quarter-turn latch and key.

2.2 MONITOR ALARM SEQUENCE

- A. Detection Level 1: Notify HVAC control workstation of detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Start ventilation system to allow occupancy by maintenance technicians to identify leaks. Cycle blue strobe lights.
- B. Detection Level 2: Notify the HVAC control workstation of the detection in the elevator machine room on a rise or fall of refrigerant concentration to this level. Operate the ventilation system for a minimum of five minutes. Cycle amber strobe lights.
- C. Detection Level 3: Notify the HVAC control workstation of the detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Sound alarm horns and

cycle red strobe lights inside and outside elevator machine room. Provide manual reset for this detection level.

- D. Sensor Fault/Trouble: Notify HVAC control workstation of fault/trouble detection in monitor.

2.3 NOTIFICATION APPLIANCES

- A. Horns: Comply with UL 464; electric-vibrating-polarized type, listed by a qualified testing agency with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn.
- B. Visible Alarm Devices: Comply with UL 1971; three color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words "REFRIGERANT DETECTION" printed in minimum 1/2-inch- high letters on the lens. Rated light output is 75 candela.

2.4 AIR-SAMPLING TUBING

- A. Annealed-Temper Copper Tubing: ASTM B 88, Type L.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with ASHRAE 15.
- B. Install air-sampling inlets, or diffusion type monitors in pits, tunnels, or trenches in machinery room that are accessible to personnel.
- C. Floor mount diffusion-type monitor, sensor/transmitters, or air-sampling inlets on slotted channel frame 12 to 18 inches above the floor in a location near the refrigerant source or between the refrigerant source and the ventilation duct inlet.
- D. Wall mount air-sampling multiple-point monitors with top of unit 60 inches above finished floor.
- E. Run air-sampling tubing from monitor to air-sampling point, in size as required by monitor manufacturer. Install tubing with maximum unsupported length of 36 inches, for tubing exposed to view. Terminate air-sampling tubing at sampling point with filter recommended by monitor manufacturer.
- F. Install air-sampling tubing with sufficient slack and flexible connections to allow for vibration of tubing and movement of equipment.
- G. Purge air-sampling tubing with dry, oil-free compressed air before connecting to monitor.
- H. Number-code or color-code air-sampling tubing for future identification and service of air-sampling multiple-point monitors.

- I. Extend air-sampling tubing from exhaust part of multiple-point monitors to inside face of exhaust plenum.
- J. Place warning signs inside and outside each door to the elevator machine room. Sample wording: "AUDIBLE AND VISUAL ALARM SOUNDING INDICATES REFRIGERANT DETECTION – DO NOT ENTER."
- K. Audible Alarm-Indicating Devices: Install at each entry door to elevator machine room, and position not less than 6 inches below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
- L. Visible Alarm-Indicating Devices: Install adjacent to each alarm horn at each entry door to elevator machine room, and position at least 6 inches below the ceiling.

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
 - 2. Test and adjust controls and safeties.
 - 3. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- C. Repair or replace malfunctioning units and retest as specified above.

3.3 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant detection devices. Refer to requirements in Division 01 specification.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of

Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 284400

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SECTION 31 10 00**Site Clearing****PART 1 – GENERAL****1.01 SUMMARY****A. Section Includes:**

1. Protecting existing plants to remain.
2. Removing existing trees.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting and capping or sealing site utilities.
7. Temporary erosion and sedimentation control measures.
8. Erosion and Sediment Control Measures.
9. Maintenance of existing drainage ditches, storm drain pipes, and storm drain structures.

1.02 MATERIAL OWNERSHIP

- A. Except for stripped topsoil or other materials indicated to remain VRE's property, cleared materials shall become Contractor's property and shall be removed from Project site. See site plans for disposal of suitable and unsuitable soils.

1.03 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from VRE and authorities having jurisdiction.
 2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on VRE's premises where indicated.
- C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- D. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place and approved as per state and local requirements.

1.04 SUBMITTALS

- A. Submit under Section 01 33 00, Submittals.
- B. Site-clearing plan indicating type of equipment to be used, methods to be employed, and where material will be hauled to for disposal.

PART 2 – PRODUCTS**2.01 SOIL MATERIALS**

- A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 Section "Earth Moving."
 - 1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

PART 3 – EXECUTION**3.01 PREPARATION**

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly flag trees and vegetation to remain or to be relocated.
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to VRE.

3.02 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction.
- B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
- C. Remove erosion and sedimentation controls after restoring and stabilizing areas disturbed during removal, as per state and local requirements.

3.03 TREE PROTECTION

- A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.
- B. Do not excavate within tree protection zones, unless otherwise indicated.
- C. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.

3.04 UTILITIES

- A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities.
- B. Existing Utilities: Do not interrupt utilities serving facilities occupied by VRE or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Architect's written permission.
- C. Removal of underground utilities is included in Division 22, Division 26, and Division 27, and Division 33.

3.05 CLEARING AND GRUBBING

- A. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.
 2. Trees, limbs and other timber having a diameter of 3 inches or greater shall be disposed of as saw longs, pulpwood, firewood, or other useable material.

3.06 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

3.07 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

3.08 DISPOSAL

- A. Disposal: Remove obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off CSX property at an approved disposal site.
 1. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION

SECTION 31 11 00

Clearing and Grubbing

PART 1 - GENERAL

1.01 SUMMARY

- A. All Clearing and Grubbing shall be governed by **SECTION 020105 CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 31 20 00**Earth Moving**

(See Also CSX 020200, CSX 020235 and CSX 020240 in Appendix A)

PART 1 – GENERAL**1.01 SUMMARY****A. Section Includes:**

1. Preparing subgrades for slabs-on-grade, pavements, and railroad tracks.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for slabs-on-grade.
4. Subbase and base course for asphalt paving.
5. Excavating and backfilling for utility trenches.

1.02 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by VRE or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated. There shall be no impact to daily operation of railroad and vehicular traffic at any time.
- B. Protect utilities, structures, and facilities designated to be protected in place from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation and backfill operations.
- C. The work shall allow rainfall to drain freely at all times.
- D. Protect against erosion within and adjacent to rights-of-way.

PART 2 - EXECUTION**2.01 EXCAVATION FOR STRUCTURES**

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

3.02 EXCAVATIONS FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.03 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.
 - 1. Clearance: 12 inches each side of pipe or conduit.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
 - 1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material, 4 inches deeper elsewhere, to allow for bedding course.

PART 4 - MEASUREMENT AND PAYMENT**4.1 MEASUREMENT**

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION

SECTION 31 20 05

Top Soil Stripping

PART 1 - GENERAL

1.01 SUMMARY

- A. All Top Soil Stripping shall be governed by **SECTION 020210 *CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS***, as included in Appendix A.

END OF SECTION

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SECTION 31 20 10

Excess Material Placement Area

PART 1 - GENERAL

1.01 SUMMARY

- A. All Excess Material Placement Areas shall be governed by **SECTION 020215 CSX *DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS***, as included in Appendix A.

END OF SECTION

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SECTION 31 23 33

Trenching and Backfilling

PART 1 - GENERAL

1.01 SUMMARY

- A. All Excess Material Placement Areas shall be governed by **SECTIONS 020245, 020220, 020225 & 020230 IN CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 31 25 00

Erosion and Sediment Control

PART 1 - GENERAL

1.01 SUMMARY

- A. All Erosion and Sediment Control shall be governed by **SECTION 020115 CSX DESIGN AND CONSTRUCTION *STANDARD SPECIFICATIONS***, as included in Appendix A.

END OF SECTION

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SECTION 31 50 00**Excavation Support and Protection
(See also Section VI and Section VII – Appendix B)****PART 1 – GENERAL****1.01 SUMMARY****A. Section Includes:**

1. This section specifies procedures, performance criteria, and requirements for Contractor to provide safe and stable excavations throughout the construction. Contractor shall provide temporary sheeting, shoring, and bracing systems as required by the work. Contractor shall meet codes, regulations, and requirements of agencies having jurisdiction over this work.
2. Work under this section includes but is not limited to:
 - a. Design of the temporary support systems that are to be employed by the Contractor.
 - b. Construction of temporary sheeting, shoring, and bracing systems.
 - c. Employing acceptable side slope layback methods for excavations.
 - d. Maintenance of bracing systems and removal.
 - e. All associated design work.
 - f. Obtaining required Federal OSHA, VOSHA, and local jurisdiction permits.

1.02 RELATED SECTIONS

- A. Section 31 20 00, Earth Moving.
- B. Section 03 20 00, Concrete Reinforcing.
- C. Section 03 30 00, Cast-in-Place Concrete.

1.03 REFERENCE STANDARDS

- A. DCSM: Prince William County Design and Construction Standards Manual.
- B. VOSHA: State of Virginia Department of Labor and Industry, VOSHA Standards
- C. AWS: American Welding Society.
- D. OSHA: Occupational Safety and Health Administration.
- E. AASHTO: American Association of State Highway and Transportation Officials.
- F. AREMA: American Railway Engineering and Maintenance of Way Association – Manual for Railway Engineering
- G. Code of Virginia – 56-265.24

1.04 SUBMITTALS

- A. Make submittals under Section 01 33 00, Submittals.
- B. General Excavation Support Procedure: Submit an outline of intended excavation support systems as required for the work. This submittal is for the Engineer's general information and in no way relieves the Contractor of complete responsibility for the successful performance of intended excavation methods.
- C. Excavation Drawings: Submit drawings of all proposed excavations.
 - 1. Include plan views indicating the extent of proposed excavations relative to the nearest track centerline.
 - 2. Include cross-sections of proposed excavations.
 - 3. Include cross-sections cut perpendicular to the track; indicate the track location and use equal horizontal and vertical scales.
 - 4. Vertical dimensions shall be relative to top of rail and horizontal elevations shall be relative to the nearest track centerline.
 - 5. Show impacted facilities (e.g., access roads, drainage ditches) and indicate how impacts shall be mitigated during construction.
 - 6. Indicate construction access locations.
- D. Sheetting and/or Shoring Drawings: Required for sheetting, shoring, and other excavation support systems.
 - 1. Drawings shall be prepared, signed, and sealed by a professional engineer licensed to practice in the Commonwealth of Virginia.
 - 2. Include plan views indicating the extent of proposed shoring relative to the nearest track centerline.
 - 3. Include cross-sections of proposed shoring.
 - 4. Include cross-sections cut perpendicular to the track; indicate the track location and use equal horizontal and vertical scales.
 - 5. Vertical dimensions shall be relative to top of rail and horizontal elevations shall be relative to the nearest track centerline.
 - 6. Drawings shall also indicate details of structural members, connection details, and embedment depths.
 - 7. Indicate construction access locations.
- E. Design Calculations: Required for sheetting, shoring and other excavation support systems; prepared, signed, and sealed by a professional engineer licensed to practice in the Commonwealth of Virginia.
- F. Installation Procedure: Required for sheetting, shoring, and other excavation support systems; prepared, signed, and sealed by a professional engineer licensed to practice in the Commonwealth of Virginia.

1.05 QUALITY CONTROL

- A. Protect all utilities, structures, and facilities designated to remain in place from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation and backfill operations.
- B. Submitted drawings, design calculations, and installation procedures for excavation support systems shall be prepared, sealed, and signed by a professional engineer licensed to practice in the Commonwealth of Virginia.

1.06 DESIGN CRITERIA

- A. Design excavation support in accordance with AASHTO and AREMA requirements, to support loads including: earth pressures, AASHTO HS20 traffic loading, AREMA Cooper E-80 Railroad Loading, utility loads, loads from adjacent structures, ground water pressure, and equipment and construction loads. No increases in allowable stresses or reductions of safety factors shall be allowed.
- B. The excavation support shall allow safe and expeditious construction of the permanent structure without movement or settlement of adjacent buildings, structures, utilities, or track work.
 - 1. In non-track areas, design the sheeting and bracing support system to support indicated loads to allow the safe and expeditious construction of the permanent structures or demolition of existing appurtenances, utilities, structures, or site utility structures without movement or settlement of the ground, and to prevent damage to, or movement or settlement of, appurtenances, structures, piers, utilities, or site utility structures that are to remain in place.
 - 2. In track areas, design the excavation and track support system to support indicated loads to allow the safe and expeditious installation of structures, appurtenances, utilities, and site utility structures; demolition of structures, site utility structures, appurtenances, and utilities to be removed; construction of the permanent structures; and other applicable work under this contract, with lateral movement or settlement of the ground of less than 0.25 inches, and to prevent damage to, or movement or settlement of, appurtenances, structures, site utility structures, utilities, or track at a distance of 10 feet or greater from the lateral support. All sheeting and bracing design shall comply with the requirements of CSXT and AREMA.
- C. Excavation and shoring systems shall be such that AREMA Cooper E-80 loading can be accommodated at all times during shoring construction. Shoring construction shall be performed without affecting railroad operations unless otherwise approved in advance by the Engineer.
- D. Temporary sheeting and shoring for support of adjacent tracks during construction shall not be closer than 8 feet 6 inches from the nearest track centerline.

E. Excavation and Shoring Requirements Within the Sheet Piling Zone:

1. The Sheet Piling Zone shall be defined as the area between the following boundaries:
 - a. A vertical line offset 8 feet 6 inches from the nearest track centerline.
 - b. A 1:1 projection beginning at a point located 8 feet 6 inches from the nearest track centerline and 2 feet below top of rail of the nearest track. The 1:1 projection shall slope down and away from the nearest track.

Un-shored excavations within the Sheet Piling Zone shall not be allowed. Shoring within the Sheet Piling Zone shall be of a type where the shoring is installed in place prior to performance of any excavation, and where the excavation can be made with no possibility of disturbance or loss of soil material retained between shoring and track. Common shoring types fulfilling this requirement are interlocking-edge sheet piling, tongue and groove edge precast concrete sheet piling, etc., which are driven or vibrated into position prior to starting any excavation. Unless otherwise indicated in the specifications, on the Drawings, or as approved by the Engineer, shoring within the Sheet Piling Zone shall be abandoned in place, except for the top 2 feet, which shall be removed and backfilled in accordance with Section 31 20 00, Earth Moving. Shoring types using lagging elements which are placed as excavation proceeds are not permitted within the Sheet Piling Zone. Shoring within the Sheet Piling Zone shall be designed for AREMA Cooper E-80 loading.

F. Excavation and Shoring Requirements Within the Shoring Zone:

1. The Shoring Zone shall be defined as the area between the following boundaries:
 - a. A 1:1 projection beginning at a point located 8 feet 6 inches from the nearest track centerline and 2 feet below top of rail of the nearest track. The 1:1 projection shall slope down and away from the nearest track.
 - b. A 1.5:1 projection beginning at a point located 11 feet from the nearest track centerline and 2 feet below top of rail of the nearest track. The 1.5:1 projection shall slope down and away from the nearest track.
2. Un-shored excavations within the Shoring Zone shall not be allowed. Shoring types using lagging elements which are placed as excavation proceeds are allowable within the Shoring Zone. Shoring within the Shoring Zone shall be designed for AREMA Cooper E-80 loading.

G. Excavation and Shoring Requirements Within the Excavation Zone:

1. The Excavation Zone shall be defined as the area that is located beyond (i.e., in a direction away from the nearest track) the following boundary:
 - a. A 1.5:1 projection beginning at a point located 11 feet from the nearest track centerline and 2 feet below top of rail of the nearest track. The 1.5:1 projection shall slope down and away from the nearest track.
2. Sloping cuts are allowed within the Excavation Zone. Excavations and shoring within the Excavation Zone are not required to be designed for railroad live loading.

H. Provide handrails.

- I. Tiebacks or other excavation support mechanisms that are installed under the track structure shall be at least 24 inches clear below top of rail.

- J. Design sheet pile and soldier pile and lagging excavation support systems to penetrate to a depth below the bottom of excavation adequate to prevent lateral and vertical earth movement, and to permit lowering of the indicated bottom of excavation at least 2 feet without any change in the support system as installed except for additional lagging and bracing for soldier pile and lagging systems.
 - 1. Soldier piles and lagging will be permitted for supporting adjacent track or tracks only when required penetration of steel sheet piling cannot be obtained.
- K. Design the bracing system to furnish sufficient reaction against side banks to maintain stability in the banks. Obtain this reaction by timely stressing to predetermined loads until the necessary reaction is produced against the banks, or by other methods necessary to prevent displacement of ground and movement of structures, tracks, site utility structures, appurtenances, and utilities.
- L. Support end banks so that compressive stresses from end banks are transmitted through diagonal braces and corner members into sidewalks or subgrade, or both.
- M. Where physical conditions of design impose insurmountable restrictions requiring the placing of sheeting closer than specified, submit the matter to Engineer for review.
 - 1. Submit alternative methods for review by Engineer.

1.07 MAINTENANCE OF RAILROAD OPERATIONS

- A. Existing tracks shall remain in operation during the work, unless otherwise permitted by CSXT.
- B. CSXT has mainline tracks adjacent to the project site, which shall remain in operation. Contractor is to maintain 25 feet clearance from centerline of mainline track. Contractor is required to notify CSXT and comply with its requirements if work is less than 25 feet from mainline track.
- C. Refer to Attachment P.5, Contractor Safety-Rules to Live By, for additional requirements when operating near railroad tracks.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Materials for excavation support systems shall conform to the submitted and approved plan and shall be new or in good used condition as approved by the Engineer. Steel structural members with existing full-penetration welds are not acceptable.
- B. All materials, whether new or used, shall be sound and free of defects that might impair their suitability for the intended use.
- C. Structural Steel: ASTM A36.

- D. Concrete and Steel Reinforcement: Conform to requirements of Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-in-Place Concrete.
 - 1. Concrete Compressive Strength: 28 day minimum compressive strength of 4000 psi.
 - 2. Maximum Aggregate Size: 3/4 inch.
- E. Steel Sheet Piling: Continuous interlocking type, ASTM A328.
- F. Timber Left in Place: Treated in accordance with AWP standards.
- G. Sand: Well graded sand as specified in Section 31 20 00, Earth Moving.

PART 3 - EXECUTION

3.01 CONTRACTOR'S RESPONSIBILITY

- A. Assess the extent of excavation support which will be required in the work, including use of side slope layback methods, sheeting, and bracing.
- B. Before commencing work, examine the drawings and specifications, inspect the site, consult all available record drawings of existing work and utilities, and note all conditions and limitations which may influence work required by this section.
- C. Carry out the work of this section in conformance with applicable laws, codes, ordinances, and regulations of local authorities, including furnishing of any required excavation drawings to those authorities and obtaining of permits.

3.02 GENERAL

- A. Install and remove excavation support systems in accordance with the accepted working drawings. Install, maintain, and remove excavation support in such a manner as to prevent movement, settlement, or loss of ground, removal of fines from the adjacent ground, or damage to or movement of adjacent structures, appurtenances, tracks, site utility structures, and utilities.
- B. Advise Engineer of the time schedule for each operation and obtain Engineer's approval for work to be performed adjacent to tracks so that it may be properly supervised by CSXT's personnel.
- C. Excavation adjacent to track shall be covered, ramped, and protected by handrails, barricades, and warning lights as directed by Engineer.
- D. Where cavities adjacent to sheet piling are created by driving of sheet piling, fill with well graded sand; immediately restore and tamp disturbed ballast.
- E. Prior to placing and driving steel sheeting, hand-dig exploratory trenches in areas where railroad and utility underground installations are known to exist. These trenches are for

location purposes only; backfill immediately after exploratory work is finished. Perform this work in presence of Engineer.

1. Make exploratory trenches 3 feet deep and 15 inches wide in the form of an "H" with outside dimensions matching the outside sheeting installations.
2. Incorporate into the work the applicable recommendations of the geotechnical report.

F. Conduct final backfilling of excavation in accordance with Section 31 20 00, Earth Moving.

3.03 STABILITY OF EXCAVATIONS

- A. Maintain safe and stable excavations at all times during execution of work. Employ side slope layback methods, bracing, and sheeting to maintain the integrity of excavations.
- B. Provide sheeting and bracing where side slope layback methods are not possible due to space restrictions or the nature of material excavated.
- C. Requirements:
 1. Comply with rules, orders, and regulations of the State of Virginia Department of Labor and Industry regarding bracing requirements for excavations.
 2. Maintain sides and slopes of excavations in safe condition until backfilling is completed.
 3. Where the Contractor elects to slope the sides of excavations, backfill of the over-excavated areas shall be made in the same manner specified for the adjacent excavated area. Additional excavation and backfill required shall be at no additional cost to CSXT and shall be placed in accordance with Section 31 20 00, Earth Moving.
 4. If ground water is present, maintain ground water level at least five feet below the excavation side slopes, and protect slopes from erosion.

3.04 SHEETING AND BRACING

- A. Provide sheeting, bracing, and other temporary protective work where necessary for safety, to prevent encroachment on adjoining property, or for the proper execution of the work.
- B. Where required for safety, under governing laws, or as directed by the Engineer, temporary sheeting shall be left in place. If so, remove original braces and re-brace sheeting against the structure in a manner approved by the Engineer. Cut off sheeting at elevations directed by the Engineer.

3.05 REMOVAL

- A. Except within the Sheet Piling Zone as noted above, do not leave in place components of the support system unless otherwise noted or directed.
- B. Do not commence removal of temporary support system until temporary protective work is no longer necessary, as determined by Contractor's Virginia-licensed engineer.

- C. Immediately fill voids created by removal of portions of the excavation support members with concrete or well graded sand.
- D. During construction, cut off sheet piling at the elevation of top of adjacent tie. After construction and backfilling has been completed, remove piling except where it is to remain in place.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION

SECTION 31 50 10

Site Work Materials

PART 1 - GENERAL

1.01 SUMMARY

- A. All Site Work Materials shall be governed by **SECTIONS 020255, 020260, 020265 AND ALL 300 SERIES PIPE AND CULVERTS IN DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 31 60 00

Track

PART 1 - GENERAL

1.01 SUMMARY

- A. All Track shall be governed by **ALL CSX 400 SERIES IN *CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS***, as included in Appendix A.

END OF SECTION

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SECTION 31 60 05

Signs

PART 1 - GENERAL

1.01 SUMMARY

- A. All Signs shall be governed by **SECTION 020135 CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 32 00 00

Temporary Structures/Falsework

PART 1 - GENERAL

1.01 SUMMARY

- A. All Temporary Structures/Falsework shall be governed by **SECTION 070205 CSX *DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS***, as included in Appendix A.

END OF SECTION

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SECTION 32 16 14**Sidewalks****PART 1 - GENERAL****1.01 SUMMARY****A. Section Includes:**

1. Manufacture, transport, and placement of curbs, gutters, and sidewalks, and related material, including labor, materials, and equipment.

B. Related Sections:

1. Section 03 10 00, Concrete Forming and Accessories.
2. Section 03 20 00, Concrete Reinforcing.
3. Section 03 30 00, Cast-in-Place Concrete.

1.02 REFERENCE STANDARDS

- A. ASTM: ASTM International (formerly American Society for Testing and Materials).
- B. VDOT: Virginia Department of Transportation 2016 Road and Bridge Standards.
- C. DCSM: Prince William County Design and Construction Standards Manual.

1.03 NOT USED**1.04 SUBMITTALS**

- A. Submit under Section 01 33 00, Submittal Procedures.
- B. Compliance: Concrete mix and materials, test reports, and manufacturer or supplier's certification that materials delivered to site are in compliance with specifications.
- C. Samples: Samples and test reports showing compliance with requirements in accordance with **the VDOT 2016 Road and Bridge Standards.**
- D. Product Data: Manufacturer's standard drawings or catalog cuts and certificate of conformance for joint filler or other materials which are specified to conform to publications referenced under "Products" in Part 2 of this section.

1.05 QUALITY ASSURANCE

- A. Establish and maintain required lines and elevations. Make gradual and smooth transitions to pavements.

PART 2 - PRODUCTS**2.01 PORTLAND CEMENT CONCRETE**

- A. Portland cement concrete for construction of curbs, gutters, and sidewalks shall conform to **the VDOT 2016 Road and Bridge Standards.**
- B. Off-Site Improvements shall comply with Spotsylvania County Standard Plans and Specifications.

2.02 REINFORCEMENT

- A. Reinforcement for this portion of the work shall conform to the provisions of Section 03 20 00, Concrete Reinforcing, and chairs shall be plastic or concrete.
- B. Off-Site Improvements shall comply with Spotsylvania County Standard Plans and Specifications.

2.03 JOINT FILLER

- A. Premolded joint fillers shall conform to **the VDOT 2016 Road and Bridge Standards.**

PART 3 – NOT USED**PART 4 - MEASUREMENT AND PAYMENT****4.1 MEASUREMENT**

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

SECTION 32 31 13

Chain Link Fences and Gates

PART 1 - GENERAL

1.01 SUMMARY

- A. All Chain Link Fences and Gates shall be governed by **SECTION 020400 CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 32 40 00

Retaining Walls

PART 1 - GENERAL

1.01 SUMMARY

- A. All Retaining Walls shall be governed by **SECTION 070305 and 070405 CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 32 50 00 - PERMANENT SOIL NAILS**PART 1 – GENERAL****1.1 DESCRIPTION**

- A. The Work shall consist of designing and constructing permanent soil nail retaining walls as specified herein and shown on the Plans. The Contractor shall design the soil nail wall and select the method of excavation, drilling method, and equipment; final drill hole diameter(s), and grouting procedures to meet the performance requirements specified herein and as specified in the Contract. Available subsurface investigation results including soil properties, strength parameters, required safety factors, boring logs, and design requirements and other criteria are as shown on the Plans and in Project Specifications, Appendix D.
- B. Soil nailing work shall include excavating in accordance with the staged lifts; drilling soil nail drill holes to the specified design length and orientation; providing, placing and grouting the encapsulated bar tendons into the drill hole; performing nail testing; placing drainage elements; placing shotcrete reinforcement; applying shotcrete facing over the reinforcement; and attaching bearing plates and nuts.
- C. The term “Soil Nail” as used herein is intended as a generic term and refers to a reinforcing bar grouted into a drilled hole installed in any type of ground. Soil nail walls are to be built from the top down in existing ground.

1.2 DESIGN CRITERIA AND FACTOR OF SAFETY

- A. Soil nail walls shall be designed and constructed in accordance with the 5th Edition of the AASHTO LRFD Bridge Design Specifications, FHWA-IF-03-017 “Geotechnical Engineering Circular No. 7”, and the Specifications except as otherwise noted herein. Alternative design criteria may be considered if approved by the Engineer.
- B. The following Factors of Safety shall be used for the design of the soil nail wall:

	Resisting Component (FHWA, GEC#7)	Symbol	Minimum Factors of Safety or Static Loads Failure Mode	
			Temporary Structure	Permanent Structure
	Global Long-Term	FS _G	1.35	1.5
External Stability	Global Stability (48 hrs of unsupported face)	FS _G	1.3	1.3
Internal Stability	Sliding	FS _{SL}	1.3	1.5
	Bearing Capacity*	FS _H	2.5	3.0
	Pullout Resistance	FS ^P	2.0	2.0
	Nail Bar Tensile Strength	FS _T	1.35	1.5
Facing Strength	Facing Flexure	FS _{FF}	1.35	1.5
	Facing Punching Shear	FS _{FP}	1.35	1.5
	H-Stud Tensile (A307 Bolt)	FS _{HT}	1.8	2.0
	H-Stud Tensile (A325 Bolt)	FS _{HT}	1.5	1.7

*Bearing capacity when using global stability software shall be evaluated using the capacity of the Global Stability Long-Term condition.

- C. Deformation criteria for the walls shall be limited to the maximum tolerable deformations indicated on the Plans unless those on the Working drawings are more restrictive. Monitoring the wall during construction shall also be performed as detailed herein.

1.3 GENERAL

- A. The soil nailing contractor shall submit a project reference list verifying the successful construction completion of at least 3 permanent soil nail retaining wall projects during the last 3 years totaling at least 5,000 square feet of wall face area and at least 200 permanent soil nails. A brief description of each project with the Owner's name and current phone number shall be included.

A Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia employed by the soil nailing contractor having experience in the construction of permanent soil nail retaining walls on at least 3 completed projects over the past 3 years shall supervise the Work. The on-site supervisor and drill rig operators shall have experience installing permanent soil nails on at least 3 projects over the past 3 years. The Contractor shall not use consultants or manufacturer's representatives to satisfy these requirements.

At least 30 days before starting the wall construction, the soil nail contractor shall submit the completed project reference list and a list identifying the supervising engineer, drill rig operators, and on-site supervisors assigned to the project. The personnel list shall contain a summary of each individual's experience and be complete enough for the Engineer to determine whether each individual satisfies the qualification requirements. The Engineer will approve or reject the soil nail contractor's qualifications within 15 calendar days after receiving a complete submission. Work shall not be started nor materials ordered until the Engineer provides written approval of the soil nail contractor's qualifications.

- B. The Contractor shall review the geotechnical report and corresponding available subsurface information and visit the site to assess the site geometry, equipment access conditions, and relocation of existing structures and above ground facilities. The Contractor shall conduct any additional subsurface investigations deemed necessary to design the selected system.
- C. Before starting any wall construction activities, the Contractor and Engineer shall inspect the site to observe and document the pre-construction site conditions, existing structures, and facilities. During construction, the Contractor shall observe the conditions above the soil nail wall on a daily basis for signs of lateral ground movement in the vicinity of the soil nail wall. Immediately notify the Engineer if signs of lateral soil movement; such as new cracks in the soil surface or structures, increased size of old cracks, or separation of joints in structures, foundations, streets, or paved and unpaved surfaces; are observed. If the Engineer determines that the movements exceed those stipulated on the working or shop drawings or identified on the Plans, the Contractor shall take corrective actions necessary to stop the movement and perform repairs.
- D. Soil nail wall construction requires excavation in staged lifts and the wall excavation contractor should consult Section 03-35-00 "Shotcrete and Permanent Concrete Facing" for details. A pre-construction meeting shall be held before the start of wall construction. The Engineer, Contractor, excavation contractor, and soil nail contractor shall attend the meeting. The pre-

construction meeting will be conducted to clarify the construction requirements for the work, to coordinate the construction schedule and activities, and to identify contractual relationships and delineate responsibilities - particularly those pertaining to wall excavation, nail installation and testing, excavation and wall alignment survey control, and shotcrete and cast-in-place facing construction. Soil nail wall staged lifts and excavation in the vicinity of the wall face requires special care and effort compared to general earthwork excavation.

1.4 SUBMITTALS

- A. Before starting the respective operation or incorporating materials referenced below, submit the following information to the Engineer for review and approval:
1. The proposed start date and proposed detailed wall construction sequence.
 2. Plan describing how surface water will be diverted, controlled, and disposed of.
 3. Proposed method and equipment for excavating the soil and/or rock, including the proposed grade elevations for each excavation lift.
 4. Measures to ensure wall and slope stability during various stages of wall construction and excavation where discontinuous rows of nails will be installed (if applicable); information on space requirements for installation equipment; temporary shoring plans (if applicable); and information on provisions for working in the proximity of underground facilities or utilities (if applicable).
 5. Anchorage design calculations and drawings with minimum bond lengths, anchor length relative to the assumed failure planes, design total load, factor of safety, and service loads. The nail layout, methods, and equipment including drill hole diameter proposed to achieve the specified pullout resistance values and any variation of these along the wall alignment. All working drawings, shop plans, and design calculations shall be signed and sealed by a Professional Engineer licensed to practice engineering in the Commonwealth of Virginia. The proposed design shall satisfy the design parameters and requirements in the plans and specifications. Complete design calculations shall include the most critical geometry and loading combination for each design section that exist during construction and at the end of construction. Approval of the Contractor's working drawings, shop plans, and design calculations shall not relieve the Contractor of any of his responsibility under the contract for the successful completion of the work.
 6. Nail grout mix design including:
 - a. Type of Portland cement.
 - b. Aggregate source and gradation.
 - c. Proportions of mix by weight and water/cement ratio.
 - d. Manufacturer, brand name, and technical literature for proposed admixtures.
 - e. Compressive strength test results (per AASHTO T106/ASTM C109) supplied by a qualified independent testing lab verifying the specified minimum 3 and 28-day grout

compressive strengths. Previous test results for the proposed grout mix completed within one year of the start of grouting may be submitted for initial verification and acceptance of the required compressive strengths at start of production work.

7. Proposed nail grout placement procedures and equipment.
8. Proposed nail testing methods and equipment setup including:
 - a. Details of the jacking frame and appurtenant bracing and design calculations for the test frame setup to ensure that the frame is capable of applying the maximum load with appropriate factor of safety.
 - b. Details showing methods of isolating test nails during shotcrete application (i.e., methods to prevent bonding of the soil nail bar and the shotcrete facing during testing).
 - c. Details showing methods of providing the temporary unbonded length and of grouting the temporary unbonded length of test nails after completion of testing.
 - d. Equipment list.
9. Identification number and certified calibration records for each test jack, pressure gauge, and load cell to be used. Jack and pressure gauge shall be calibrated as a unit. Calibration records shall include the date tested, device identification number, and the calibration test results and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 90 days prior to submittal.
10. Manufacturer Certificates of Compliance for the soil nail centralizers and encapsulation.
11. Contractor shall state on their working or shop plans the anticipated soil nail wall movement at the wall's highest elevation. This movement amount shall be less than or equal to the movement indicated on the Plans, and will be considered the threshold value to evaluate wall performance by the Engineer.
12. Instrumentation monitoring plan and manufacturer's information of the instrumentation:
 - a. Walls retaining more than 20-feet of earth constructed in a top down method or if specified on the Working drawings or Plans shall be monitored for horizontal and vertical movement. Wall monitoring (horizontal and vertical movement) shall be performed weekly as a minimum and the data shall be plotted time versus movement. A contingency plan shall be developed and submitted for review if movements during construction reach an unacceptable level as specified in the Working drawings.

The contingency plan shall use the following action thresholds:

- a. If horizontal movement at the top of the wall reaches 80% of the maximum allowable value, increase movement monitoring frequency to 3 times weekly and provide data to Engineer the same day for evaluation.
- b. If horizontal movement at the top of the wall reaches 100% of the maximum allowable value, stop wall backfilling activities and consult the Engineer for potential remedial action.

13. Upon delivery of nail bars to the project site, provide certified mill test results for nail bars from each heat specifying the minimum ultimate strength, yield strength, elongation, and composition.
- B. The Contractor shall not begin wall construction or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the Engineer. Changes or deviations from the approved submittals must be submitted for approval.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Soil Nails:
 1. Solid Bar Nail Tendons: AASHTO M31/ASTM A615, for Grade 60 or 75, deformed bar, continuous without splices or welds, new, straight, undamaged, encapsulated. Threaded a minimum 6 inches on the wall anchorage end to allow proper attachment of bearing plate and nut. Threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g. Dywidag or Williams continuous threadbars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the Contractor shall consider the reduced effective bar area in the wall design.
 2. Hollow Core Tendons: Continuous bars without splices or welds. Drilling bit, bar and hex nuts shall be new, straight, undamaged. Threading at the anchorage shall allow proper attachment of bearing plate and nut. Threading should be continuous spiral deformed ribbing provided by the bar deformations (e.g. Dywidag or Titan.) Mill certifications of the maximum yield and ultimate loads are required for the bar. Bar, drilling bits, and nuts used should match the size and strength of the bars.
 3. Couplers, if used, shall be guaranteed minimum 1.25 ultimate tensile strength of the tendon. Couplers shall be new, and straight, and sized to fit the tendon.
- B. Encapsulation: Minimum 30 mils corrugated HDPE tube conforming to AASHTO M252 or corrugated PVC tube conforming to ASTM D1784, Class 13464-B. Encapsulation shall provide at least 0.50 inches of grout cover over the nail bar and be resistant to ultra violet light degradation, normal handling stresses, and grouting pressures. Factory encapsulation is preferred. The encapsulation may be field fabricated if done in strict accordance with the manufacturer's recommendations after approval by the Engineer.
- C. Centralizers: Manufactured from Schedule 40 PVC pipe or tube, or other material not detrimental to the nail steel (wood shall not be used); securely attached to the nail bar; sized to position the nail bar within 1 inch of the center of the drill hole; sized to allow tremie pipe insertion to the bottom of the drill hole; and sized to allow grout to freely flow up the drill hole.
- D. Nail Grout: Neat cement or sand/cement mixture with a minimum 3 day compressive strength of 1,500 psi and a minimum 28-day compressive strength of 3,000 psi per AASHTO T106/ASTM C109.

- E. Admixtures: AASHTO M194/ASTM C494. Admixtures which control bleed, improve flowability, reduce water content and retard set may be used in the grout subject to review and acceptance by the Engineer. Accelerators are not permitted. Expansive admixtures may only be used in grout used for filling sealed encapsulations. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's instructions.
- F. Cement: Shall conform to Appendix A, Section 070105 of the Specifications.
- G. Fine Aggregate: Shall conform to Appendix A, Section 070105 of the Specifications.
- H. Corrosion Protection:

Corrosion protection for the project is considered Class A in accordance with FHWA GEC#7, maximum corrosion protection. If encapsulation of the tendon is not feasible, an alternative incorporating a sacrificial reinforcing thickness or epoxy approved by the Engineer may be incorporated into the design in lieu of encapsulation.

The service life of the structure shall be considered a minimum of 75 years for sizing the reinforcing for corrosion protection for permanent structures.

2.2 MATERIALS HANDLING AND STORAGE

- A. Store cement to prevent moisture degradation and partial hydration. Do not use cement that has become caked or lumpy. Store aggregates so that segregation and inclusion of foreign materials are prevented. Do not use the bottom 6 inches of aggregate piles in contact with the ground.
- B. Store steel reinforcement on supports to keep the steel from contact with the ground. Nail steel with damage as a result of abrasion, cuts, nicks, welds, and weld splatter will be rejected by the Engineer. Do not ground welding leads to the nail bars. Protect nail steel from dirt, rust, and other deleterious substances before installation. Heavy corrosion or pitting of nails will be rejected by the Engineer. Light rust that has not resulted in pitting is acceptable. Place protective wrap over anchorage end of nail bar to which bearing plate and nut will be attached to protect during handling, installation, grouting, and concreting.
- C. Do not move or transport encapsulated nails until encapsulation grout has reached sufficient strength to resist damage during handling. Handle encapsulated nails in a manner that will prevent large deflections, distortions, or damage. Repair encapsulated nails that are damaged or defective in accordance with manufacturer's instructions or remove from the site.

PART 3 – INSTALLATION

3.1 CONSTRUCTION REQUIREMENTS

- A. Site Drainage Control

Provide positive control and discharge of all surface water that will affect construction of the soil nail retaining wall. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water. Upon substantial completion of the wall, remove surface water control pipes or conduits from the site. Alternatively, with the approval of

the Engineer, pipes or conduits that are left in place may be fully grouted and abandoned.

Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Capture surface water runoff flows and flows from existing subsurface drainage structures independently of the wall drainage network and convey them to an outfall structure or storm sewer, as approved by the Engineer.

B. Excavation

Coordinate the work and the excavation and construct the soil nail wall such that unraveling of the unsupported face does not occur. Perform the wall construction and excavation sequence in accordance with the approved working plans.

C. Excavation and Wall Alignment

The Contractor shall provide the necessary survey and alignment control during excavation of each lift, locate and drill each drill hole within the allowable tolerances and perform the wall excavation and nail installation in a manner which allows for constructing the shotcrete construction facing to the specified minimum thickness and such that the finished concrete structural facing can be constructed to the specified minimum thickness shown in the Working drawings and to the line and grade indicated in the Plans and Working Drawings. Where the as-built location of the front face of the shotcrete exceeds the allowable tolerance from the wall control line shown on the Plans and Working Drawings, the Contractor shall determine remedial measures necessary to provide proper attachment of nail head bearing plate connections and satisfactory placement of the final facing, as called for on the Plans and Working drawings.

D. Soil Nail Wall Structure Excavation

Complete clearing, grubbing, grading, removing a portion of the existing slope, if applicable, and excavation above and behind the wall before beginning wall construction. Do not over excavate the original ground behind the wall or at the ends of the wall. Do not perform general excavation that will affect the soil nailing work. The excavation shall proceed from the top down in a horizontal staged excavation lift sequence with the ground level for each lift excavated no more than mid-height between adjacent nail rows.

It is critical that the Contractor construct a smooth vertical face for the installation of soil nails and construction of the wall.

The Contractor shall ensure as little disturbance as possible outside the limits of excavation. Over excavation not authorized by the Engineer shall be corrected by the Contractor.

The Contractor shall restore all structure, slabs, paved areas, slope protection, etc., that may be opened or damaged in performance of the work included in this Contract. Except where noted otherwise on the plans, work shall match existing.

Excavate to the wall face using procedures that (1) prevent over excavation; (2) prevent ground loss, swelling, air slacking, or loosening; (3) prevent loss of support for completed portions of the wall; (4) prevent loss of soil moisture at the face; and (5) prevent ground freezing.

The exposed unsupported excavation face cut height shall not exceed the vertical nail spacing

plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Complete excavation to the final wall excavation line and application of the shotcrete in the same work shift unless otherwise approved by the Engineer. Application of the shotcrete may be delayed up to 24 hours if the Contractor can show that the delay will not adversely affect the excavation face stability. A polyethylene film over the face of the excavation may reduce degradation of the cut face caused by changes in the moisture. Damage to existing structures or structures included in the work shall be repaired by the Contractor.

Excavation to the next lift shall not proceed until nail installation, reinforced shotcrete placement, attachment of bearing plates and nuts, and nail testing has been completed and accepted in the current lift. Nail grout and shotcrete shall have cured for at least 72 hours or attained at least their specified 3 day compressive strength before excavating the next underlying lift. Excavating the next lift in less than 72 hours will only be allowed if the Contractor submits compressive strength test results, for test performed by a qualified independent testing lab, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strengths in the lesser time.

Notify the Engineer immediately if raveling, excessive movement, or local instability of the wall face excavation occurs. Unstable areas shall be temporarily stabilized by buttressing the exposed face with an earth berm or other methods. Suspend work in unstable areas until remedial measures are developed.

E. Wall Discontinuities

Where the Contractor's excavation and installation methods result in a discontinuous wall along any nail row, the ends of the constructed wall section shall extend beyond the ends of the next lower excavation lift by at least 10 feet. Slopes at these discontinuities shall be constructed to prevent sloughing or failure of the temporary slopes. If sections of the wall are to be constructed at different times, prevent sloughing or failure of the temporary slopes at the end of each wall section.

F. Excavation Face Protrusions, Voids, or Obstructions

Remove all or portions of cobbles, boulders, rubble or other subsurface obstructions encountered at the wall final excavation face which will protrude into the design shotcrete facing. Determine method of removal of face protrusions, including methods to safely secure remnant pieces left behind the excavation face and for promptly backfilling voids resulting from removal of protrusions extending behind the excavation face. Notify the Engineer of the proposed methods for removal of face protrusions at least 24 hours prior to beginning removal. Voids overbreak or over excavation beyond the plan wall excavation line resulting from the removal of face protrusions or excavation operations shall be backfilled with shotcrete or concrete, as approved by the Engineer.

G. Nail Installation

Determine the required drill hole diameter(s), drilling method, grout composition and installation method necessary to achieve the design nail pullout resistance(s) specified in the Working drawings. The Design Test Load shall be in accordance with the nail testing acceptance criteria in Section 3.1 (L) Verification Test Nails.

No drilling or installation of production nails will be permitted in any soil or rock unit until

successful pre-production verification testing of nails is completed in that unit and approved by the Engineer. Install verification test nails using the same equipment, methods, nail inclination, and drill hole diameter as planned for the production nails. Perform pre-production verification tests in accordance with the Section 3.1L Verification Test Nails before starting wall excavation and before installing production nails in the specific lift in which the designated verification test nails are located. Verification nails will be considered as adequate production nails in the final wall section if they meet the criteria established in Section 3.1 (N) Test Nail Acceptance Criteria. The number and location of the verification tests shall be as specified herein. Verification test nails may be installed through either the existing slope face before starting wall excavation, drill platform work bench, stabilization berm, or into slot cuts made for the particular lift in which the verification test nails are located. Slot cuts shall only be large enough to safely accommodate the drill and test nail reaction setup. Subject to the Engineer's approval, verification test nails may also be installed at different locations than specified, as long as the Contractor can demonstrate that the test nails will be bonded into ground which is representative of the ground at the designated verification test nail locations.

Install the production soil nails before applying the reinforced shotcrete facing unless otherwise approved by the Engineer in writing. The Contractor may request such approval for the placing shotcrete facing before drilling and installing the nails. If approved, provide a block out through the shotcrete facing at each drill hole location using PVC pipe or other suitable materials, to prevent damage to the facing during drilling. As part of the required construction submittals, provide the Engineer with acceptable structural design calculations demonstrating that the facing structural capacity will not be reduced and that the bearing plates are adequate to span the nail drill hole block out through the construction facing.

Where necessary for stability of the excavation face, the Contractor may place a sealing layer (flashcoat) of un-reinforced shotcrete or steel fiber reinforced shotcrete or drill and grout nails through a temporary stabilizing berm of native soil to protect and stabilize the face of the excavation.

The Contractor may add, eliminate, or relocate nails to accommodate actual field conditions subject to the Engineers approval.

H. Drilling

The drill holes for the soil nails shall be made at the locations in the Contractor's approved wall design submittal. Select drilling equipment and methods suitable for the ground conditions described in the boring logs. Select drill hole diameter(s) required to develop the specified pullout resistance and to also provide a minimum 1-inch grout cover over the encapsulated nails encapsulation. The Contractor shall determine the final drill hole diameter(s) required to provide the specified pullout resistance. Using drilling muds such as bentonite slurry to assist in drill cutting removal is not allowed, but air may be used. If approved by the Engineer, the Contractor may use water or foam flushing upon successful demonstration that the installation method still provides adequate nail pullout resistance. If caving ground is encountered, use cased drilling methods to support the sides of the drill holes. Where hard drilling conditions such as rock, cobbles, boulders, or obstructions are encountered, percussion or other suitable drilling equipment capable of drilling and maintaining stable drill holes through such materials shall be used.

Immediately suspend or modify drilling operations if ground subsidence is observed, if the soil nail wall is adversely affected, or if adjacent structures are damaged from the drilling operation.

Immediately stabilize the adverse conditions.

I. Nail Tendon Installation

Provide nail tendons in accordance with the Contractor's approved wall design submittal. Provide centralizers sized to position the bar within 1 inch of the center of the drill hole. Position centralizers so their maximum center-to-center spacing does not exceed 10 feet. Also locate centralizers within 2 feet from the top and bottom of drill hole. Securely attach centralizers to the bar so that they will not shift during handling or insertion into the drill hole yet will still allow grout tremie pipe insertion to the bottom of drill hole and allow grout to flow freely up the hole.

Inspect each nail tendon before installing and repairing or replacing damaged bars or corrosion protection. Check uncased drill holes for cleanliness before inserting the soil nail tendon. Insert nail tendon with centralizers to the required length without difficulty and in a way that prevents damage to the drill hole, tendon, or corrosion protection. Do not drive or force partially inserted soil nails into the hole. Remove nails which cannot be fully inserted to the design depth and clean the drill hole to allow unobstructed installation.

When using cased or hollow-stem auger equipment which does not allow for centralizers to pass through the casing or augerstem, the Contractor may delete the centralizers if the neat cement grout pumped through the casing is placed using grout pressures greater than 145 psi or if the sand-cement grout placed through the stem of the auger has a slump of 9 inches or less.

J. Nail Installation Tolerances

Nails shall not extend beyond the permanent easement limits shown on the Plans. Nail location and orientation tolerances are:

Nail head location, deviation from the design location:	6 inches any direction
Nail inclination, deviation from plan:	+ or – 3 degrees

Location tolerances are applicable to only one nail and not accumulative over large wall areas.

Center nail bars within 1 inch of the center of the drill hole.

Soil nails which do not satisfy the specified tolerances due to installation methods shall be replaced. Backfill abandoned nail drill holes with tremied grout. Nails which encounter unanticipated obstructions during drilling shall be relocated as approved by the Engineer.

K. Grouting

Use a neat cement grout or sand-cement grout. Submit the proposed nail grout mix design to the Engineer for review and approval in accordance with the Section 1.4 Submittals. The design mix submittal shall include compressive strength test results verifying that the proposed mix will have a minimum 3-day compressive strength of 1,500 psi and a minimum 28-day compressive strength of 3,000 psi.

Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths for installation of preproduction verification test nails and initial production nails. During production, nail grout

shall be tested by the Contractor in accordance with AASHTO T106/ASTM C109 at a frequency of no less than one test per day of grout placed. Provide grout cube test results to the Engineer within 24 hours of testing.

Grout the drill hole after installing the nail bar. Each drill hole shall be grouted within 2 hours of completing drilling, unless otherwise approved by the Engineer. Inject the grout at the lowest point of each drill hole through a grout tube, casing, hollow-stem auger, or drill rods. Keep the outlet end of the conduit delivering the grout below the surface of the grout as the conduit is withdrawn to prevent creation of voids. Completely fill the drill hole in a continuous operation. Cold joints are not allowed in the grout column. The grout tube may remain in the hole if it is filled with grout. Grouting before insertion of the nail is allowed provided the nail bar is immediately inserted through the grout to the specified length without difficulty. Secondary grouting may also be performed if the secondary grout tubes are filled with grout upon completion.

Maintain sufficient grout level within the casing to offset the external groundwater and soil pressure and prevent drill hole caving during casing removal from drill holes advanced by either cased or hollow-stem auger methods. Maintain grout head or grout pressures sufficient to ensure that the drill hole will be completely filled with grout pressures for soil nails installed using pressure grouting techniques. Control grout pressures to prevent excessive ground heave or fracturing.

Remove the grout and nail if grouting is suspended for more than 30 minutes or does not satisfy the requirements of this Specification, the Plans, or working or shop plans, and replace with fresh grout and undamaged nail.

L. Verification Test Nails

Perform pre-production design verification testing of 2% soil nails or a minimum of 8 soil nails per wall, whichever is greater. Perform pre-production verification test on test nails at locations determined by the Contractor (4 locations minimum). The remaining verification test nails may be performed during construction. Engineer shall approve test nail locations. Verification test nail locations shall be indicated in the submittal.

Required nail test data will be recorded by the Engineer. Do not perform nail testing until the nail grout and shotcrete facing have cured for at least 72 hours and attained at least their 3-day compressive strength. Testing in less than 72 hours will only be allowed if the Contractor submits compressive strength test results, for test performed by a qualified independent testing lab, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strengths in the lesser time.

Testing equipment shall include dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and reaction frame. Provide description of test setup and jack, pressure gauge and load cell calibration curves in accordance with Section 1.4 Submittals.

Design the testing reaction frame to be sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur. If the reaction frame will bear directly on the shotcrete facing, design it to prevent cracking of the shotcrete. Independently support and center the jack over the nail bar so that the bar does not carry the weight of the testing equipment.

Apply and measure the test load with a hydraulic jack and pressure gauge, the pressure gauge shall be graduated in 50 psi increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Monitor the nail load during verification tests with both the pressure gauge and load cell. Use the load cell to maintain constant load hold during the creep test load hold increment of the verification test.

Measure the nail head movement with a dial gauge capable of measuring to 0.0010 inch. Visually align the gauge to be parallel with the axis of the nail and support the gauge independently from the jack, wall or reaction frame. Use two dial gauges when the test setup requires reaction against a soil cut face.

Align the jack, bearing plates, and stressing anchorage with the bar; provide sufficient jack ram travel space; and set the dial gauge with enough travel space so that unloading and repositioning of the equipment will not be required during the test.

Pre-production verification testing shall be performed before installing production nails to verify the Contractor's installation methods and pullout resistance. Verification nails shall be considered as adequate production nails in the final wall section if they meet the criteria established in Section 3.1 (N) Test Nail Acceptance Criteria.

Develop and submit the details of the verification testing arrangement including the method of distributing test load pressures to the excavation surface (reaction frame), test nail bar size, grouted drill hole diameter and reaction frame dimensioning to the Engineer for approval in accordance with Section 1.4 Submittals. Construct verification test nails using the same equipment, installation methods, nail inclination, and drill hole diameter as planned for the production nails. Changes in the drilling or installation method may require additional verification testing as determined by the Engineer.

Test nails shall have both bonded and unbonded lengths. Only the bonded length of the test nail shall be grouted before testing. The unbonded test nail length shall be at least 3 feet. The bonded length of the test nail shall be determined based on the production nail bar grade and size such that the allowable nail structural load is not exceeded during testing but shall not be less than 10 feet. The allowable nail structural load during testing shall not be greater than 90 percent of the yield strength. The Contractor shall provide larger verification test nail sizes if required to safely accommodate the 10 foot minimum test bond length and testing to 2 times the allowable pullout resistance requirement.

The verification test bonded length L_{gv} shall not exceed the test allowable bar structural load divided by 2 times the allowable pullout resistance value. The following equation shall be used for determining the verification test nail maximum bonded length to be used to avoid structurally over stressing the verification test nail bar size:

$$L_{gv} = (C_f y A_s) / 2 Q_d, \text{ or } 10 \text{ feet, whichever is greater}$$

Where L_{gv}	Maximum Verification Test Nail Bond Length (feet)
$C =$	0.9 for Grade 60 and 75 bars
F_y	Bar Yield Stress
$=$	(kips/in ²) Bar
$\phi =$	Pullout resistance safety factor

Q_d = Allowable pullout resistance (kips/foot, kips per lineal foot of grouted nail length, specified herein or per the Design-Builder's soil nail design)

The Design Test Load (DTL) during verification testing shall be determined by the following equation.

$$DTL = L_{gv} \times Q_d$$

Where: DTL = Design Test Load (kips)
 L_{gv} = As-built bonded test length (feet)
 Q_d = Allowable pullout resistance (kips/foot, kips per lineal foot of grouted nail length, per the Design-Builder's soil nail design)

Verification test nails shall be incrementally loaded to a maximum test load of 200 percent of the Design Test Load (DTL) in accordance with the following loading schedule. The soil nail movements shall be recorded at each load increment.

VERIFICATION TEST LOADING SCHEDULE

<u>LOAD</u>	<u>HOLD TIME</u>
AL (0.05 DTL max.)	1 minute
0.25 DTL	10 minutes
0.50 DTL	10 minutes
0.75 DTL	10 minutes
1.00 DTL	10 minutes
1.25 DTL	10 minutes
1.50 DTL (Creep Test)	50 minutes
1.75 DTL	10 minutes
2.00 DTL (Max. Test Load)	10 minutes

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of the Design Test Load (DTL). Dial gauges should be set at “zero” after the alignment load has been applied.

Each load increment shall be held for at least 10 minutes. The verification test nail shall be monitored for creep at the 1.50 DTL load increment. Nail movements during the creep portion of the test shall be measured and recorded at the 1 minute, 2, 3, 5, 6, 10, 20, 30, 50 minutes. The load during the creep test shall be maintained within 2 percent of the intended load by use of the load cell.

M. Proof Testing of Production Nails

Proof testing shall be performed on at least 5% of the production nails. At least one Proof test shall be performed per row per 200 linear feet of wall. The proposed Proof tests shall be identified on the Working drawings.

Production proof test nails shall have both bonded and temporary unbonded lengths. Only the bonded length of the test nail shall be grouted before testing. The temporary unbonded length of the test nail shall be at least 3 feet. The bonded length of the test nail shall be determined based on the production nail bar grade and size such that the allowable bar structural load is not exceeded during testing, but shall not be less than 10 feet. Production proof test nails shorter than 13 feet in length may be constructed with less than the minimum 10 foot bond length with the unbonded length limited to 3 feet. The allowable bar structural load during testing shall not be greater than 90 percent of the yield strength for Grade 60 and Grade 75 bars.

The proof test bonded length LBP shall not exceed the test allowable bar load divided by 1.5 times the allowable pullout resistance value, or above minimum lengths, whichever is greater. The following equation shall be used for sizing the proof test nail bonded length to avoid overstressing the production nail bar size:

$$LBP = (CfyAs)/1.5Qd, \text{ or above minimum lengths, whichever is greater}$$

Where LBP = Maximum Proof Test Nail Bonded Length (feet)
 C = 0.9 for Grade 60 and 75 bars
 Fy = Bar Yield Stress
 = (kips/in²) Bar
 1.5 = Pullout resistance safety factor
 Qd = Allowable pullout resistance (kips/foot, kips per lineal foot of grouted nail length, specified herein or per the Design-Builder's soil nail design)

The Design Test Load (DTL) during proof testing shall be determined by the following equation:

$$DTL = LBP \times Qd$$

Where DTL = Design Test Load (kips)
 LBP = As-built bonded test length (feet)

Qd = Allowable pullout resistance (kips/foot, kips per lineal foot of grouted nail length, specified herein or per the Design-Builder's soil nail design)

MTL = Maximum Test Load (kips)

Proof tests shall be performed by incrementally loading the proof test nail to a maximum test load of 150 percent of the Design Test Load (DTL). The nail movement at each load will be measured and recorded by the Engineer in the same manner as for verification tests. The test load shall be monitored by a jack pressure gauge with a sensitivity and range meeting the requirements of pressure gauges used for verification test nails. At load increments other than maximum test load, the load shall be held long enough to obtain a stable reading defined as a reading that does not vary more than 0.04 inches in 10 minutes. Incremental loading for proof tests shall be in accordance with the following loading schedule. The soil nail movements shall be recorded at each load increment.

PROOF TEST LOADING SCHEDULE

<u>LOAD</u>	<u>HOLD TIME</u>
AL (.05 DTL max.)	10 min and until Stable
0.25 DTL	10 min and until Stable
0.50 DTL	10 min and until Stable
0.75 DTL	10 min and until Stable
1.00 DTL	10 min and until Stable
1.25 DTL	10 min and until Stable
1.50 DTL (Max. Test Load)	See Below

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of the Design Test Load (DTL). Dial gauges should be set to "zero" after the alignment load has been applied.

All load increments shall be maintained within 5 percent of the intended load. Depending on performance, either 10 minute or 60 minute creep tests shall be performed at the maximum test load (1.50 DTL). The creep period shall start as soon as the maximum test load is applied and the nail movement shall be measured and recorded at 1 minute, 2, 3, 5, 6, and 10 minutes. Where the nail movement between 1 minute and 10 minutes exceeds 0.04 inch, the maximum test load shall be maintained an additional 50 minutes and movements shall be recorded at 20 minutes, 30, 50, and 60 minutes.

N. Test Nail Acceptance Criteria

A test nail shall be considered acceptable when:

1. For verification tests, a total creep movement of less than 0.08 inch per log cycle of time between the 6 and 60 minute readings is measured during creep testing and the creep rate is linear or decreasing throughout the creep test load hold period.
2. For proof tests, a total creep movement of less than 0.04 inch is measured between the 1 and 10 minute readings or a total creep movement of less than 0.08 inch is measured between the 6 and 60 minute readings and the creep rate is linear or decreasing throughout

the creep test load hold period.

3. The total measured movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.
4. A pullout failure does not occur at the maximum test load. Pullout failure is defined as the load at which attempts to further increase the test load simply result in continued pullout movement of the test nail. The pullout failure load shall be recorded as part of the test data. Successful proof tested nails meeting the test acceptance criteria above may be incorporated as production nails, provided that (1) the unbonded length of the test nail drill hole has not collapsed during testing, (2) the minimum required drill hole diameter has been maintained, (3) the specified corrosion protection is provided, and (4) the test nail length is equal to or greater than the required production nail length. Test nails meeting these requirements shall be completed by satisfactorily grouting up the unbonded test length. Maintaining the temporary unbonded test length for subsequent grouting is the Contractor's responsibility. If the unbonded test length of production proof test nails cannot be satisfactorily grouted subsequent to testing, the proof test nail shall become sacrificial and shall be replaced with an additional production nail.

O. Test Nail Rejection

If a test nail does not satisfy the acceptance criterion, the Contractor shall determine the cause. The Engineer will evaluate the results of each verification test. Installation methods which do not satisfy the nail testing requirements will be rejected. The Contractor shall propose alternative methods and install replacement verification test nails.

The Engineer may require the Contractor to replace some or all of the installed production nails between a failed proof test nail and the adjacent passing proof test nail. Alternatively, the Engineer may require the installation and testing of additional proof test nails to verify that adjacent previously installed production nails have sufficient load carrying capacity. Contractor modifications may include, but are not limited to; installing additional proof test nails; increasing the drill hole diameter to provide increased capacity; modifying the installation or grouting methods; reducing the production nail spacing from that shown on the Contractor's approved submittal and installing more production nails at a reduced capacity; or installing longer production nails if sufficient right-of-way is available and the pullout capacity behind the failure surface controls the allowable nail design capacity. The nails may not be lengthened beyond the temporary construction easements or the permanent right-of-way shown on the Plans.

P. Nail Installation Records

Records documenting the soil nail wall construction will be maintained by the Engineer, unless specified otherwise. The Contractor shall provide the Engineer with as-built drawings showing as-built nail locations and as-built shotcrete facing line and grade within 5 days after completion of the shotcrete facing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION

SECTION 32 92 00

Turf and Grasses

PART 1 - GENERAL

1.01 SUMMARY

- A. All Turf and Grasses shall be governed by **SECTION 020120 CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 32 92 05

Erosion Control Matting

PART 1 - GENERAL

1.01 SUMMARY

- A. All Erosion Control Matting shall be governed by **SECTION 020120 CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS**, as included in Appendix A.

END OF SECTION

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SECTION 32 92 10

Silt Fence

PART 1 - GENERAL

1.01 SUMMARY

- A. All Silt Fence shall be governed by **SECTION 020130 *CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS***, as included in Appendix A.

END OF SECTION

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SECTION 33 01 00**Maintenance of Utilities****PART 1 - GENERAL****1.01 SUMMARY**

- A. Section Includes:
 - 1. Maintenance, support, and protection of existing underground utilities as indicated.
 - 2. Accessories required for a complete installation.

1.02 SUBMITTALS

- A. Submit under Section 01 33 00, Submittals.
- B. Prepare construction and installation plans for utility protection systems and submit to Engineer for review and approval.

1.03 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Utility protection system work shall be performed and completed in accordance with code and with requirements of utility agencies and authorities having jurisdiction. Contractor shall be responsible for obtaining standards and for compliance with applicable standards.

1.04 SITE CONDITIONS

- A. Field-locate existing utilities by contacting MISS Utility (1-800-552-7001). Check field-located utilities with the composite utility plans. Maintain existing utilities and protect from damage as necessary to satisfy requirements of utility jurisdiction and related codes and regulations.
- B. Existing invert elevations shown on sanitary sewer and storm drain profiles are based on available data. At no additional cost and prior to work, verify existing invert elevations and inform Engineer of discrepancies.
- C. Do not operate, disconnect, or shut down any part of existing utilities and services, except by permission of authorities having jurisdiction. Submit schedule of estimated shut-down time to obtain such permission, and notify all interested parties, neighbors, utilities, and municipal and county authorities, as required.
- D. Utilities to be removed shall not be removed until shut-down time can be kept to a minimum. Do not remove an existing utility line or service until the replacement line, crossover, or capping is ready to be performed.

- E. Provide shoring, underpinning, and structural support for existing utility lines and structures that become suspended or otherwise unsupported because of adjacent excavation operations.
- F. Make provisions for temporary utility services as required.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION**3.01 REQUIRED NOTIFICATIONS**

- A. Underground utilities shall be marked for identification by affected utility companies before excavation or other work is performed close to any underground pipeline, conduit, duct, wire, or other structure. Notify Engineer and utility owners before performing such excavation work. Notify affected utilities a minimum of 2 and a maximum of 10 business days before digging by calling MISS Utility (1-800-552-7001). For utility owners not covered by this telephone number, call the affected utility owners directly.
- B. Protect active underground utilities from damage. If underground utilities are damaged in any way, notify Engineer and affected utilities immediately for corrective action.

PART 4 - MEASUREMENT AND PAYMENT**4.01 DESCRIPTION**

- A. This work will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION

SECTION 33 11 16**Site Water Utility Distribution Piping****PART 1 - GENERAL****1.01 SUMMARY**

- A. Section Includes:
 - 1. Pipe and fittings for site water line including domestic water line and fire water line Valves.
 - 2. Hydrants.
 - 3. Positive displacement meters.
 - 4. Backflow preventers.
 - 5. Underground pipe markers.
 - 6. Bedding and cover materials.
- B. Related Requirements:
 - 1. Section 03 30 00 - Cast-In-Place Concrete: Concrete for thrust restraints.
 - 2. Section 22 11 00 - Facility Water Distribution: Product and execution requirements for domestic water piping at building.

1.02 REFERENCE STANDARDS

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. American Society of Mechanical Engineers:
 - 1. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
 - 2. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- C. American Society of Sanitary Engineering:
 - 1. ASSE 1012 - Backflow Preventer with Intermediate Atmospheric Vent.
 - 2. ASSE 1013 - Reduced Pressure Principle Backflow Preventers.
- D. ASTM International:
 - 1. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
- E. American Welding Society:
 - 1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
- F. American Water Works Association:
 - 1. AWWA C104 - American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 - 2. AWWA C111 - American National Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

3. AWWA C151 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
 4. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service.
 5. AWWA C502 - Dry-Barrel Fire Hydrants.
 6. AWWA C504 - Rubber-Sealed Butterfly Valves.
 7. AWWA C508 - Swing-Check Valves for Waterworks Service, 2 in. (50 mm) Through 24 in. (600 mm) NPS.
 8. AWWA C509 - Resilient-Seated Gate Valves for Water-Supply Service.
 9. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
 10. AWWA C606 - Grooved and Shouldered Joints.
 11. AWWA C700 - Cold-Water Meters - Displacement Type, Bronze Main Case.
 12. AWWA C701 - Cold-Water Meters - Turbine Type, for Customer Service.
 13. AWWA C702 - Cold-Water Meters - Compound Type.
 14. AWWA C706 - Direct-Reading, Remote-Registration Systems for Cold-Water Meters.
 15. AWWA M6 - Water Meters - Selection, Installation, Testing, and Maintenance.
- G. Underwriters Laboratories Inc.:
1. UL 246 - Hydrants for Fire - Protection Service.

1.03 SUBMITTALS

- A. Section 01 33 00 - Submittals: Requirements for submittals.
- B. Product Data: Submit data on pipe materials, pipe fittings, valves and accessories.

1.04 CLOSEOUT SUBMITTALS

- A. Section 01 33 00 - Submittals: Requirements for submittals.
- B. Project Record Documents: Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations.
- C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.05 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Perform Work in accordance with Virginia Department of Transportation standards.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 - Products: Requirements for transporting, handling, storing, and protecting products.
- B. Deliver and store valves in shipping containers with labeling in place.

PART 2 - PRODUCTS**2.01 WATER PIPING**

- A. Ductile Iron Pipe: AWWA C151.
 - 1. Fittings:[Ductile iron, standard thickness.
 - 2. Joints: AWWA C111, rubber gasket with rods.

2.02 BUTTERFLY VALVES

- A. 2 inches to 24 inches AWWA C504, iron body, bronze disc, resilient replaceable seat, water or lug ends, [ten] [infinite] position lever handle.

2.03 HYDRANT

- A. Hydrant: In accordance with Prince William County Fire Department requirements.

2.04 BACKFLOW PREVENTERS

- A. Reduced Pressure Backflow Preventers:
 - 1. Comply with ASSE 1013.
 - 2. Bronze body, with bronze internal parts and stainless steel springs.
 - 3. Two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve opening under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.
- B. Double Check Valve Assemblies: Comply with ASSE 1012; Bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.

2.05 UNDERGROUND PIPE MARKERS

- A. Plastic Ribbon Tape: Bright colored, continuously printed, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

PART 3 - EXECUTION**3.01 EXAMINATION**

- A. Closeout Requirements: Requirements for installation examination.
- B. Verify building service connection and municipal utility water main size, location, and invert are as indicated on Drawings.

3.02 PREPARATION

- A. Closeout Requirements: Requirements for installation preparation.
- B. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.

- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare pipe connections to equipment with flanges or unions.

3.03 BEDDING

- A. Excavate pipe trench in accordance with Section 31 23 33 for Work of this Section.
- B. Place fill material in accordance with Section 31 23 33.

3.04 INSTALLATION - PIPE

- A. Group piping with other site piping work whenever practical.
- B. Install ductile iron piping and fittings to AWWA C600.

3.05 INSTALLATION - VALVES AND HYDRANTS

- A. Set valves on compacted soil.
- B. Center and plumb valve box over valve. Set box cover flush with finished grade.
- C. Set hydrants plumb; locate pumper nozzle perpendicular to and facing roadway.
- D. Set hydrants to grade, with nozzles at least 20 inches above ground.
- E. Locate control valve 4 away from hydrant.
- F. Provide drainage pit 36 inches square by 24 inches deep filled with 2 inch washed gravel. Encase elbow of hydrant in gravel to 6 inches above drain opening. Do not connect drain opening to sewer.
- G. Paint hydrants in accordance with Section 09 91 00.

3.06 INSTALLATION - METERS

- A. Install positive displacement meters in accordance with AWWA M6, with isolating valves on inlet and outlet.

3.07 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Flush and disinfect system in accordance with Prince William County and AWWA requirements. Provide report upon completion.

3.08 FIELD QUALITY CONTROL

- A. Section 01 46 00 - Quality Control.

PART 4 - MEASUREMENT AND PAYMENT**4.01 DESCRIPTION**

- A. Work of this section will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.

END OF SECTION

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SECTION 33 41 00**Storm Drainage Utilities****PART 1 - GENERAL****1.01 SUMMARY**

- A. This Section includes gravity-flow, nonpressure storm drainage outside the building, with the following components:
 - 1. Precast concrete manholes and catch basins.
 - 2. Underdrains.
 - 3. Storm drain piping.

1.02 PERFORMANCE REQUIREMENTS

- A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: 10-foot head of water.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For manholes and catch basins. Include plans, elevations, sections, details, and manhole frames and covers and catch basin frames and grates.
- C. Coordination Drawings: Show pipe sizes, locations, and elevations.
- D. Field quality-control test reports.
- E. Product Data: For each type of product indicated.

PART 2 - PRODUCTS**2.01 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining

materials.

B. NOT USED.

2.03 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, with bell-and-spigot or groove and tongue ends for gasketed joints with ASTM C 443, rubber gaskets.

1. Class II, Wall B.
2. Class III, Wall B.
3. Class IV, Wall B.
4. Class V, Wall B.

2.04 PVC PIPE AND FITTINGS

A. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

B. PVC Sewer Pipe and Fittings, NPS 18 and Larger: ASTM F 679, T-2 wall thickness, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.05 PERFORATED-WALL PIPES AND FITTINGS

A. Perforated PE Pipe and Fittings: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.

1. Couplings: Manufacturer's standard, band type.

B. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.

2.06 SOLID-WALL PIPES AND FITTINGS

A. PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, bell-and-spigot ends, for gasketed joints.

1. Gaskets: ASTM F 477, elastomeric seal.

2.07 GEOTEXTILE FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

1. Structure Type: Nonwoven, needle-punched continuous filament or woven, monofilament or multifilament.
2. Style(s): Flat and sock.

2.08 SPECIAL PIPE COUPLINGS

- A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant metal tension band and tightening mechanism on each end.
 - 1. Unshielded Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant metal tension band and tightening mechanism on each end.
 - 2. Shielded Flexible Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant metal tension band and tightening mechanism on each end.
- B. Sleeve Materials:
 - 1. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 2. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- C. Unshielded Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dallas Specialty & Mfg. Co.
 - b. Fernco Inc.
 - c. Logan Clay Products Company (The).
 - d. Mission Rubber Company; a division of MCP Industries, Inc.
 - e. NDS Inc.
 - f. Plastic Oddities, Inc.
- D. Shielded Flexible Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cascade Waterworks Mfg.
 - b. Dallas Specialty & Mfg. Co.
 - c. Mission Rubber Company; a division of MCP Industries, Inc.
- E. Ring-Type Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fernco Inc.

- b. Logan Clay Products Company (The).
- c. Mission Rubber Company; a division of MCP Industries, Inc.

2.09 **MANHOLES**

- A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints. See pages 334100-12 & 13, Plates 106.01 and 106.07
 - 1. Diameter: 48 inches minimum, unless otherwise indicated.
 - 2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
 - 3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
 - 4. Riser Sections: 4-inch minimum thickness, and of length to provide depth indicated.
 - 5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 - 6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
 - 7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
 - 8. Steps: As per Virginia Department standards and specifications, see page 334100-14, Plate 106.09, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 48 inches.
 - 9. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
 - 10. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
 - 11. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch-minimum width flange and 26-inch-diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
 - a. Material: ASTM A 536, Grade 60-40-18 ductile or ASTM A 48, Class 35 gray iron, unless otherwise indicated.

2.10 **CONCRETE**

- A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
 - 1. Cement: ASTM C 150, Type II.
 - 2. Fine Aggregate: ASTM C 33, sand.
 - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
 - 4. Water: Potable.
- B. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.11 CATCH BASINS

- A. Standard Precast Concrete Catch Basins, see page 334100-15, Plate 104.01: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 1. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
 2. Top Section: Eccentric-cone type unless flat-slab-top type is indicated.
 3. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
- B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch ID by 7- to 9-inch riser with 4-inch minimum width flange, and 26- inch- diameter flat grate with small square or short-slotted drainage openings.
 1. Grate Free Area: Approximately 50 percent, unless otherwise indicated.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

- A. Pipe couplings and fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
 1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping, unless otherwise indicated.
 - a. Unshielded flexible couplings for same or minor difference OD pipes.
 - b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
 - c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
- B. Gravity-Flow, Nonpressure Sewer Piping: Use the following pipe materials for each size range:
 1. NPS 3 to NPS 6: PVC sewer pipe and fittings, gaskets, and gasketed joints.
 2. NPS 8 to NPS 15: PVC sewer pipe and fittings, gaskets, and gasketed joints.
 3. NPS 18 to NPS 30: PVC sewer pipe and fittings, gaskets, and gasketed joints.
 4. NPS 12 to 18: RCP sewer pipe and fittings, gaskets, and gasketed joints.
- C. Underground Subdrainage Piping:
 1. Perforated PE pipe and fittings, couplings, and coupled joints.

2. Perforated PVC sewer pipe and fittings for loose, bell-and-spigot joints.

3.02 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. Install gravity-flow, nonpressure drainage piping according to the following:
 1. Install piping pitched down in direction of flow, at minimum slope of 0.50 percent, unless otherwise indicated.
 2. Install piping NPS 6 and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
 3. Install piping with 24-inch minimum cover.
 4. Install piping below frost line.
 5. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 6. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
 7. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
- F. Clear interior of piping and manholes of dirt and superfluous material as work progresses.
- G. Tunneling/Direct Bore: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both. See "Virginia Department of Transportation Road and Bridge Specifications 2002" Section 302.03.a.1. Use protective sleeve to protect pipe from loads above.

3.03 NOT USED

3.04 FOUNDATION DRAINAGE INSTALLATION

- A. Excavate for underdrain drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches

between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.

- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
- E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for subdrainage.
- F. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
- G. After satisfactory testing, cover drainage piping to width of at least 6 inches on side and above top of pipe to within 12 inches of finish grade.
- H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- I. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.
- J. Place initial backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Final backfill to finish elevations and slope away from rails and buildings.

3.05 UNDERDRAIN PIPING INSTALLATION

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
 - 1. Underslab Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent.
 - 2. Lay perforated pipe with perforations down.
 - 3. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install PE piping according to ASTM D 2321.
- D. Install PVC piping according to ASTM D 2321.

3.06 PIPE JOINT CONSTRUCTION

- A. Basic pipe joint construction is specified in Division 33 Section "Common Work Results for Utilities." Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
- B. Join gravity-flow, nonpressure drainage piping according to the following:
 - 1. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-gasket joints.
 - 2. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.07 MANHOLE CONSTRUCTION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

3.08 CATCH BASIN INSTALLATION

- A. Set frames and grates to elevations indicated.

3.09 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping to building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping."
- B. Make connections to existing piping and underground manholes.
 - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
- C. Drawings indicate general arrangement of piping, fittings, and specialties.
- D. Connect low elevations of underdrain system to solid-wall-piping storm drainage system.

3.10 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate report for each system inspection.
 - 2. Defects requiring correction include the following:

- a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
1. Do not enclose, cover, or put into service before inspection and approval.
 2. Test completed piping systems according to requirements of authorities having jurisdiction.
 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 4. Submit separate report for each test.
 5. Air Tests: Test storm drainage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
- C. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.
- E. Testing: After installing drainage course to top of underdrain piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

3.11 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. For underdrains, maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

PART 4 - MEASUREMENT AND PAYMENT

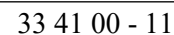
4.01 DESCRIPTION

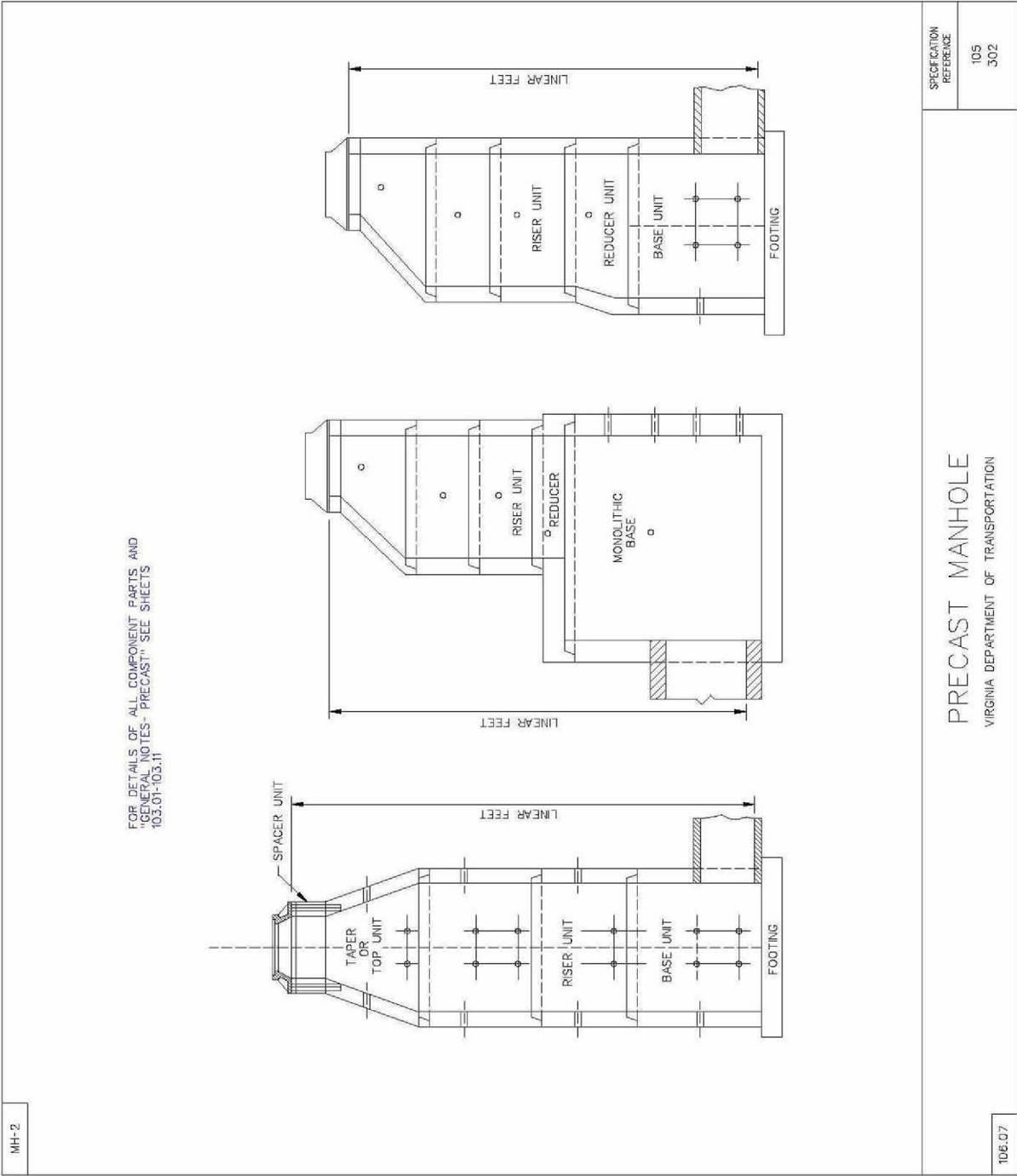
- A. The payment for the Storm Piping items specified in the Contract Documents will be measured in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable "Pay Item" and in accordance with the "Method of Measurement and

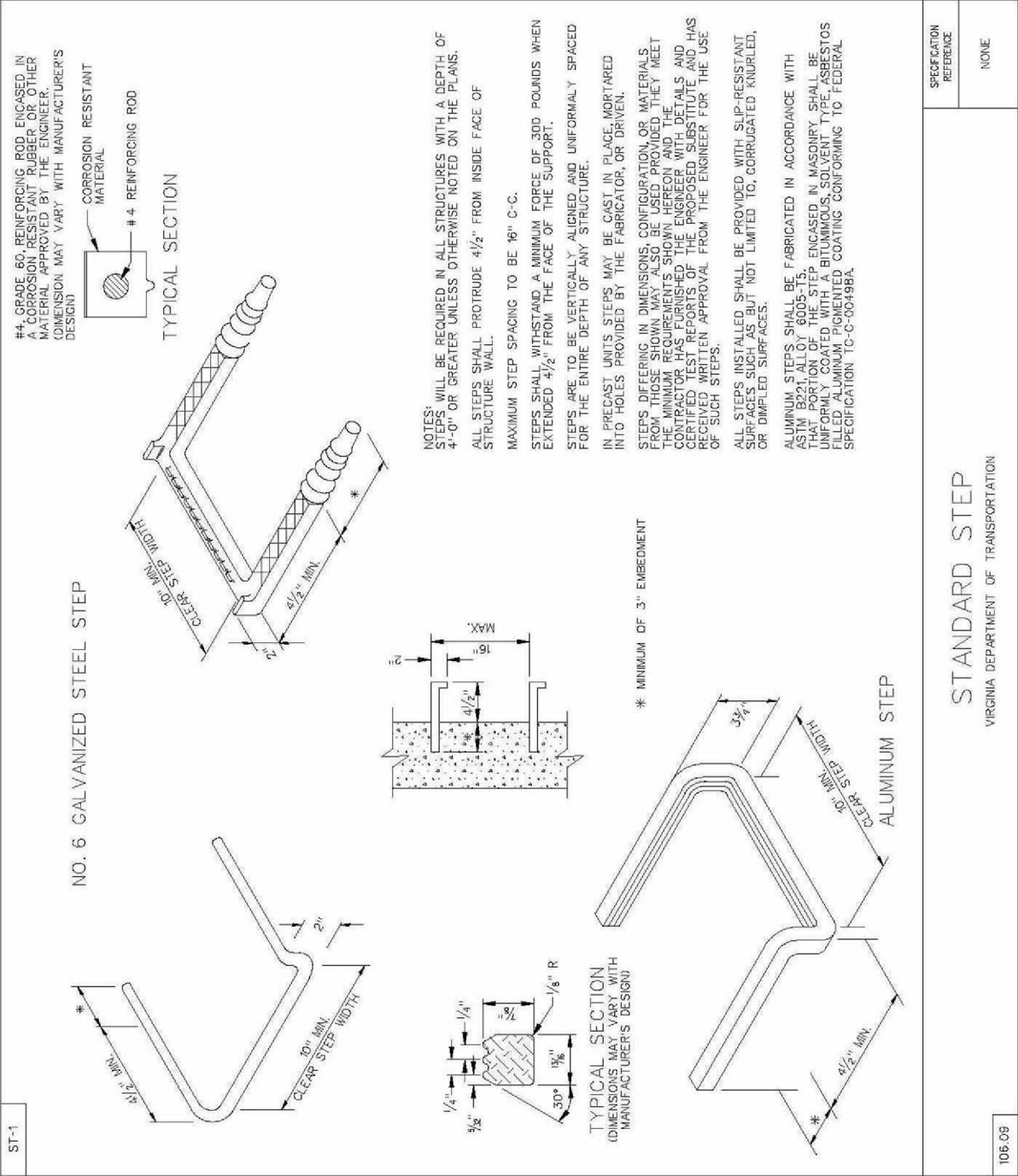
Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans and will be full compensation for all applicable excavation, sheeting, shoring, dewatering, hauling, invert paving, storing, protective sleeves where required, connections to existing and proposed structures, rehandling of material, removal and disposal of excess and unsuitable material, tamped fill, forming bed or foundation, backfill, compaction and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

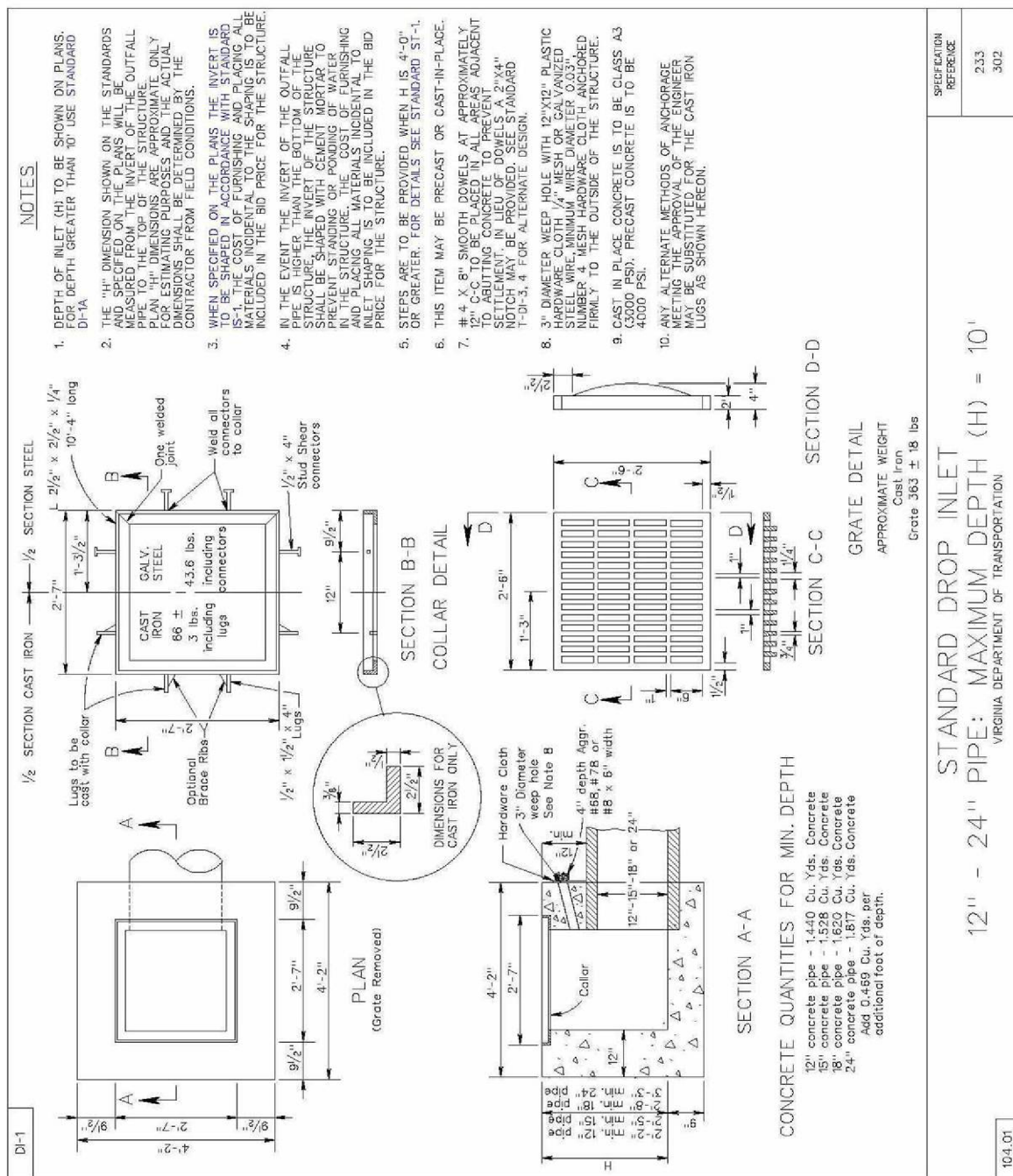
- B. The payment for inlets and manholes will not be measured and will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans and will be full compensation for all excavation, concrete, masonry, special or precast units, reinforcement, ladder rungs, drip stones, No. 57 aggregate, underdrain stubs, frames, grates and covers, grade and slope adjustments, backfill and for all material, labor, equipment, tools, and incidentals necessary to complete the work.
- C. Pipe, of all material types, will not be measured and will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- D. Pipe connections and elbows, bends and tees shall incidental to the cost of pipes.
- E. Manholes will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- F. Standard Inlets will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans.
- G. Underdrain pipes will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans for all excavation, pipe, coupling bands, aggregate, backfill, geotextile, video inspection and for all material, labor, equipment, tools, and

H. Direct Bore will be measured in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & QUANTITIY SUMMARY of the plans. Payment will include full compensation for sheeting, shoring, bracing for protecting the rail bed and all material, labor, equipment, tools, and incidentals necessary to complete the work.









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SECTION 33 71 19 – ELECTRICAL HANDHOLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Furnishing and installing electrical handholes as shown on drawings and as required by code and as specified.
2. Excavation and backfill, accessories including covers, raceway labeling and drainage.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M105 – Standard Specification for Gray Iron Castings (ASTM A48).

1.3 SUBMITTALS

- A. Submit under Section 01 33 00, Submittals, and Section 26 05 26, Grounding and Bonding for Electrical Systems.
- B. Product Data:
 1. Concrete dampproofing compound.
 2. Cover inscription wording.
- C. Shop Drawings:
 1. Handholes (each type) including cover and frame.

PART 2 - PRODUCTS

2.1 PRECAST CONCRETE HANDHOLES

- A. Provide precast handholes with 28-day, 4500 psi or greater compressive strength concrete and designed for AASHTO HS20 loading.
 1. Minimum Dimensions for Handholes: As indicated on drawings.
 2. Use extension sections to increase vertical dimensions to those shown on drawings.
- B. Slope floors toward drain points leaving no pockets or other non-draining areas.
 1. Provide a drainage outlet at the low point of the floor constructed with a heavy cast iron, slotted or perforated cover grate.

- C. Provide raceway entrances on all four sides.
 - 1. Knockout panels or precast individual raceway openings may be used.
 - 2. On sides where no raceways are installed under this contract, provide knockout panels for future raceway installation.
 - 3. Provide knockout(s) for ground rods.
- D. For handholes, provide heavy duty frames and covers suitable for HS20 street loading, unless otherwise indicated on drawings.
 - 1. Type: Diamond plate covers.
 - 2. Design: Solid top.
 - 3. Handles: Two apiece.
- E. Identify covers using an inscription.
 - 1. Locate inscription for circular cast covers on the upper side of each cover, and feature integral cast-in letters not less than 2 inches high.
 - 2. Where galvanized steel diamond plate covers are furnished, weld the identification lettering to each cover prior to galvanizing.
- F. Provide steel handhole hardware, hot-dip galvanized after fabrication.
- G. Factory applied coal-tar bitumastic damp-proofing compound, one coat on all outside surfaces.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Excavation and Bedding:
 - 1. Excavate to a depth that will accommodate the overall assembled height of the handhole and bedding as shown on drawings.
 - 2. Overexcavate at least 12 inches around the sidewalls of handholes.
 - 3. Provide round drain rock for drainage.
 - 4. Install bedding consisting of 1 foot minimum of 3/4-inch minus crushed rock, grade level, and compact in accordance with Section 31 20 00, Earth Moving.
 - 5. Completely dewater excavation in accordance with Section 31 20 00, Earth Moving, before setting handholes.
 - 6. Notify Engineer seven days in advance of installation of each handhole.
 - a. Obtain approval of excavation and bedding before installing handhole.

3.2 INSTALLATION

- A. Inspection and Setting:

1. Assemble handhole by lowering into the excavation.
2. Bring handhole to required finish grade.
3. Have completed handhole approved by Engineer before backfilling.

B. Backfilling:

1. Provide backfill around all handholes consisting of good compactable material such as 3/4-inch minus crushed rock, sand, or clean earth fill containing no rocks larger than 3/4 inch.
2. Verify that no voids remain between handhole walls and native soil excavation.
3. Do not backfill until handhole is completely assembled, and make certain to compact the backfill progressively from the bottom to the top surface.

C. Grouting:

1. Grout risers, covers, and raceway entering handholes with non-shrink cement grout consisting of two parts sand, one part cement, and sufficient water to form a heavy plastic slurry.
2. Apply grout so as to ensure filling of all voids in the joint being sealed.

3.3 IDENTIFICATION

A. Identify each handhole with numbers shown on drawings.

B. Identify each duct entering handhole.

1. Provide 2 inch high numbers stenciled with black paint on white paint background, and located as shown on drawings.
2. Use exterior latex masonry type paint.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Measurement of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

4.2 PAYMENT

- A. Payment of the work of this section will be in accordance with the "Method of Measurement and Payment" description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY on the plans.

END OF SECTION 33 71 19

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APPENDIX A

CSX DESIGN AND CONSTRUCTION STANDARD SPECIFICATIONS



DIVISION 2 – SITE WORK AND TRACK CONSTRUCTION **TABLE OF CONTENTS**

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100 Series: Site Preparation

020105	Clearing and Grubbing	August 1, 2018
020110	Seeding, Mulching, and Soil Supplements	June 15, 2015
020115	Soil Sedimentation and Erosion Control	September 11, 2018
020120	Erosion Control Matting	June 15, 2015
020130	Silt Fence	June 15, 2015
020135	Signage	August 1, 2018

200 Series: Earthwork

020200	Earthwork	August 1, 2018
020210	Topsoil Stripping	August 1, 2018
020215	Excess Material Placement Area (EMPA)	August 1, 2018
020220	Backfilling (For use with CMP and RCP)	June 15, 2015
020225	Backfilling (For Perforated CMP)	June 15, 2015
020230	Backfilling (For Perforated CMP with FilterFabric)	June 15, 2015
020235	Off Site Borrow Material	August 1, 2018
020240	Unsuitable Soils	August 1, 2018
020245	Trench Excavation	June 15, 2015
020255	Rip-Rap (Random Placement)	June 15, 2015
020260	Geo Grid (Roadbed Stabilization)	June 15, 2015
020265	Filter Fabric	June 15, 2015

300 Series: Pipes and Culverts

020300	Subdrainage Systems (Trench Drains)	June 15, 2015
020305	Drainage Pipe (Perforated C.M.P.)	June 15, 2015
020310	Corrugated Metal Pipe	August 20, 2018
020315	Reinforced Concrete Catch Basin	June 15, 2015
020320	Corrugated Metal Catch Basin	June 15, 2015
020325	Reinforced Concrete Pipe (R.C.P.)	June 15, 2015
020330	Concrete Box Culvert	August 20, 2018
020340	Jack and Bore Steel Pipe Culvert	August 20, 2018

400 Series: Track

020400	Chain Link Fences & Gates	June 15, 2015
020401	Grade Crossings	June 15, 2015
020405	Railroad Subballast	June 15, 2015
020410	Railroad Ballasting	August 1, 2018
020415	Track Layout	June 15, 2015



PART 1 - GENERAL

1.1 DESCRIPTION

- A. The entire area in which work is to be performed, either by CONTRACTOR, the railroad or both shall be cleared and grubbed under this item.
- B. Clearing and Grubbing shall conform to the following:
 - 1. Clearing and grubbing shall include the work of removing from the construction site all trees, brush, and stumps. Stump removal may be omitted in areas that are to receive more than five (5) feet of fill.
 - 2. Clearing shall apply for the entire area of the roadway, stream channels, ditches, yards, station grounds, and other areas within the limits of the project, including borrow pits, if applicable.
 - 3. Trees removed under this item shall become the property of CONTRACTOR, unless otherwise indicated on the plans or stated in the proposal, and the disposal of the trees, cuttings, stumps including the major root system within two feet of the ground surface, and all other items not required for reuse in construction, shall be disposed of by CONTRACTOR outside the limits of CSXT right-of-way where the material will cause no obstruction to the flood channels of streams and will not detract from the appearance of the roadbed. All root mats shall be removed to a depth of not less than two feet below the existing surface.
 - 4. Clearing and grubbing shall progress a sufficient distance in advance of the grading to permit cross-sectioning and setting of slope stakes.
 - 5. All materials accumulated by the clearing and grubbing operation shall be removed from the property of CSXT. Merchantable timber shall become the property of CONTRACTOR unless otherwise specified.
 - 6. In localities having special regulations relative to the removal and disposal of infected trees or other matter, CONTRACTOR shall consult the proper authority and proceed with the removal in the approved manner.
 - 7. The removal and disposal of all materials shall be performed without injury to property of CSXT or others, except as modified in this section.
- C. Clearing shall consist of the cutting of all trees stumps, brush, shrubs and other vegetation at a level not more than six (6) inches above the existing ground, as well as the subsequent disposal of all cut material and other fallen timber, fallen branches and other surface litter. Cut off should be horizontal to the ground without leaving sharp edges and spear type remains.
- D. All low-hanging and/or unsound branches on trees or shrubs shall be removed. All branches overhanging the railroad roadbed are to be trimmed so as to provide a twenty-three (23) foot vertical clearance above the top of rail at all distances within twenty-five (25) feet from the centerline of proposed track.
- E. Where necessary, CONTRACTOR will be responsible for permitting and clearing an area beyond the limits shown on plans so as to provide sufficient room for all trades to perform their work. This work will be at CONTRACTOR's expense and accountability.
- F. Grubbing shall consist of the removal and disposal of all stumps, roots, embedded logs and all boulders and debris visible on the surface. Boulders may be disposed of within the railroad right-of-way as designated by ENGINEER.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item CLEARING & GRUBBING shall be in acres measured to the nearest tenth which have been actually cleared, grubbed and authorized by the ENGINEER. Measurement shall include all areas of excavation and embankment to ten feet beyond toe of slopes and top of cuts or as shown on the plans and extend to the toe of the ballast. Temporary access and haul roads; Contractor laydown and material areas; and all other areas cleared due to the Contractor's means and methods will not be included in the measurement.
- B. Payment for the item CLEARING & GRUBBING shall be at the unit price bid and be full compensation for supplying all labor, materials, equipment, tools, and all else necessary to clear, grub, measure, dispose of materials, and all else necessary.

PART 2 - PRODUCTS

- A. Not used.

PART 3 - EXECUTION

3.1 EXECUTION

- A. All the material removed under this item becomes the property of CONTRACTOR. This material shall be hauled, at CONTRACTOR's expense, off the railroad's property. If a waste area is established on the railroad's property, CONTRACTOR may waste the material there in a manner satisfactory to ENGINEER and in accordance with all federal, state and local laws.
- B. CONTRACTOR may elect to burn combustible material in areas where burning is permitted. After first obtaining all necessary permits, CONTRACTOR may burn combustible material in a manner safe to all concerned. Ashes produced by burning shall be treated as waste material and be disposed of accordingly.
- C. Where excavation is required, the site shall be grubbed to a depth equal to a minimum of two (2) feet below the proposed subgrade or slope surfaces except at locations where the depth of excavation precludes the execution of this item.
- D. Where fill is required and the proposed embankment subgrade and slopes are less than five (5) feet above the existing ground, the site shall be grubbed to a minimum depth of two (2) feet below the existing ground.
- E. Where fill is required and the proposed embankment subgrade and slopes are equal to or more than five (5) feet above the existing ground, CONTRACTOR may forego the grubbing of sound stumps, roots and non-perishable objects. Stumps, roots, and non-perishable objects which are not grubbed must not extend more than six (6) inches above the original ground line.
- F. All trees and stumps are to be cut a minimum of six (6) inches below the existing ground line at locations under a proposed embankment or within ten (10) feet of the toe of slope of a proposed embankment
- G. Except in areas to be excavated, all depressions and holes created by the removal of stumps, roots and objectionable material shall be backfilled and compacted prior to the placement of fill material.

END OF SECTION 020105



PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish all plant, tools, materials, equipment, labor and supervision and perform all tasks to furnish and grade topsoil, furnish and place seed, fertilizer, lime, mulch, and other materials, etc. at the locations as shown on, or required by, the drawings, as specified herein, and/or as directed by ENGINEER.
- B. Contractor should follow Local/State DOT specs, however, if state specification is not appropriate, use the following materials.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of item SEEDING & MULCHING shall be by the Acre for which a satisfactory stand of grass has been initiated for all areas directed by the Engineer to be planted for final seeding. Temporary seeding shall be in erosion control section item.
- B. Payment for item SEEDING & MULCHING shall be at the unit price bid for the acreage on which a satisfactory stand of grass has been initiated as directed by the Engineer and be full compensation for all labor, equipment, tools, materials, supplies and all else necessary.

PART 2 - MATERIALS

2.1 TOPSOIL

- A. Reusable topsoil shall be limited to friable loam, reasonably free of subsoil, clay lumps, brush, roots, weeds or other objectionable vegetation, stones or similar objects larger than one inch in any dimension, litter, or other materials unsuitable or harmful to plant growth, and shall not contain less than 5% nor more than 20% organic matter, as determined by current AASHTO Designation T-194.

- B. Furnished topsoil shall conform to the following grade analysis:

Sieve	Minimum Percent Passing
2"	100
No. 4	80
No. 10	60

- C. Sand, silt, and clay material passing the No. 10 sieve shall be as defined by current AASHTO Designation M 146 and shall be present within the following ranges:

	Minimum Percent	Maximum Percent
Sand	0	75
Silt	10	95
Clay	5	20

2.2 FERTILIZER AND LIMESTONE

- A. Fertilizer shall be 5-20-20 at 800 pounds per acre or 0-20-20 at 800 pounds per acre with an additional 40 pounds per acre of nitrogen derived from organic matter.
- B. Lime shall be agricultural limestone (pulverized).

2.3 SEED

- A. Seed mixtures shall have the following consistency:

Formula and Species	Percent by Weight (%)	Minimum Percent (%)		Max. Percent Weed Seed (%)
		Purity	Germination	
Creeping Red Fescue	15	98	85	0.15
Timothy	20	98	85	0.15
Alsite Clover	20	97	90	0.10
Perennial Rye Grass	20	98	90	0.15
Birdsfoot Trefoil	15	98	80	0.10
Wild White Clover	10	97	90	0.10

- B. CONTRACTOR may also use the governing State's DOT Seed Formula in lieu of the above specified seed mixture.

2.4 MULCH

- A. Mulches for seeded areas shall be one or a combination of the following (or as indicated or specified): hay, straw, wood cellulose, rotted manure, or any substance submitted by CONTRACTOR and approved by ENGINEER.
- B. Hydro-mulch will be anchored with a plastic base soil adhesive, such as "Soil-Saver" or an approved equal as directed by ENGINEER.
- C. Mulching shall be free from mature seed-bearing stalks or roots of prohibited or noxious weeds as defined by the State Department of Agriculture and DOT for which the project is situated.

PART 3 - EXECUTION

3.1 GENERAL

- A. Mechanical application of the seed, fertilizer, lime, mulch and mulch anchorage by hydro-seeding is acceptable. Alternative methods of mechanical applications shall be approved by ENGINEER.
- B. CONTRACTOR shall be responsible for the maintenance of all seeded and mulched areas until the entire project has been completed and accepted. This shall include the watering of all areas seeded until such time as growth has occurred and acceptance given. Acceptable grass seed growth shall be blade growth of over three inches and a corresponding quantity of root growth very near the ratio of 1 to 1. RAILROAD reserves the right to test this seed growth in a manner that will yield the true grass system growth.
- C. All areas outside the grading limits, where the vegetative growth has been disturbed or destroyed by operations of CONTRACTOR, shall be conditioned, limed, fertilized and seeded as required for the project with formulas and rates typical of the project and mulched in accordance with these Specifications. The cost of this treatment will be borne by CONTRACTOR.

3.2 TOPSOIL

- A. For slopes and areas possessing sufficient topsoil, scarify and loosen soil surfaces to a depth of six (6) inches lateral to the face of the slope. Loosened topsoil shall be moistened, if dry, immediately prior to placing seed. The area shall be cleared of all stones and/or debris two (2) inches or larger.

- B. Slopes and other areas requiring topsoil shall be dressed and shaped to provide for uniform placement of the topsoil. These areas shall be cleared of all stones and/or debris two (2) inches or larger in any dimension and shall be loosened to a depth of two inches. The topsoil shall then be spread over the prepared areas in such quantities as necessary to obtain the four inch depth after natural settlement and compaction and shall be raked free of all material unsuitable for or harmful to plant growth. It shall then be compacted by means of a roller weighing not more than 120 pounds per foot width. Immediately prior to placing of the topsoil, the area shall be wetted thoroughly.
- C. Topsoil shall not be placed over frozen ground.

3.3 FERTILIZER AND LIMESTONE

- A. Upon completion of the topsoil placement, agricultural pulverized limestone and fertilizer shall be applied uniformly to the soil areas specified to be so treated. On all topsoiled areas, the lime and fertilizer application shall be incorporated into the soil to a depth of at least two inches.
- B. Lime shall be applied at a rate of two (2) tons per acre.
- C. The soil will have a minimum pH of 6.0. If this is not met by the soil prior to seeding, the soil shall be chemically treated so that the soil pH will be brought above 6.0.

3.4 SEEDING

- A. Seed shall be applied at a rate of seventy-five (75) pounds per acre.
- B. Seeding shall be performed within the following seeding dates or as approved in writing by ENGINEER:
 - 1. March 1 to June 1
 - 2. August 1 to October 1
- C. All seeds proposed to be used shall meet the approval of the state's Department of Agriculture and DOT for the state in which the project is located. RAILROAD reserves the right to test, reject or accept all seed delivered to the project site. All seeds are to be furnished in separate varieties, separately packaged or bagged, and shall be labeled, tagged or marked with identifying characteristics.
- D. Once the fertilizer and lime have been worked into place, the seeding shall be done to the quantity and limits as specified herein. Seed shall be uniformly sown on the designated areas and "broomed" into the soil to a depth of 1/8-inch. ENGINEER shall check the quantity and uniformity of application.
- E. After the seed has been sown, all soil areas 3:1 and flatter shall be rolled immediately with an approved roller weighing not more than 65 pounds per foot of width.

3.5 MULCHING

- A. Mulch shall be applied at the rate of 3 tons per acre or hydro-mulch as approved by ENGINEER.
- B. Mulch shall be placed within 24 hours of seeding. It shall be placed at the thickness and/or rate per Acre as specified or as proposed by CONTRACTOR and approved by the ENGINEER.
- C. Mulches that are removed from the surface by wind or other natural causes as determined by ENGINEER shall be replaced and anchored by a means approved by ENGINEER and at no additional cost to the RAILROAD.

END OF SECTION 020110

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. This work includes placement, maintenance, and later removal, of sedimentation, dust, and erosion control facilities that are shown on the plans, permits, and/or are required by federal, state, and local agencies. This includes but is not limited to the following items: construction ingress/egress; water quality monitoring and sampling; temporary ditch checks; and straw bale barriers.

1.2 SITE DESCRIPTION

The project consists of the construction of the following:

- A. Proposed Track No. 1 to tie to the Existing Track no. 2
- B. Proposed Track No. 3 in new location
- C. Existing Track No. 2 to be resurfaced, relocated or upgraded.
- D. Retaining Wall 13
- E. All grading, drainage, required for construction of track corridor and station elements.
- F. Proposed new station, passenger platforms and passenger bridge including modifications to the existing station as required.
- G. At-grade crossing of Potomac Avenue (new Track No. 3 crossing and relocated Track No. 2 crossing).

Sequence of construction is in accordance with the Plans.

Total land area of the site is approximately 4.40 acres. Total area disturbed by excavation and grading is approximately 1.65 acres. Runoff coefficient of existing railroad track ballast area is assumed to be 0.35 and of open vegetated areas is 0.35. Runoff coefficients at project completion for each respective area are approximately equivalent to pre-disturbance conditions. Soil profiles are described in boring logs, Appendix C and Appendix D.

Contractor operations will generate potential sources of pollution which may include but are not limited to storage area for materials, temporary storage of construction debris and salvaged materials, vehicle fueling area and temporary sanitary waste facilities.

Runoff from the construction site will be received by the Potomac River.

Plans and drawings contain the following information:

- A. Drainage patterns and cross-sections
- B. Limits of construction activity
- C. Seeding plans
- D. Erosion control plans and details
- E. Location of surface waters and wetland areas

1.3 SUBMITTALS

- A. CONTRACTOR must follow the provisions of the approved plan and the project Stormwater Pollution Prevention Plan (SWPPP) including the most recent General Erosion & Sediment Control Standards and Specifications for CSX Transportation (approved annually by VA DEQ) and related VDOT Road and Bridge Specifications and Standards.

A construction schedule for erosion control shall be submitted to ENGINEER for review and approval before any work is begun.

PART 2 - CONTROLS

2.1 Erosion & Sediment Control shall be in accordance with CSX Transportation Erosion and Sediment Control Plan, VDOT Road and Bridge Specifications, 2016 and the plans.

If sediment escapes the construction site, offsite accumulations of sediment must be removed to minimize offsite impacts. Litter, construction debris and construction chemicals exposed to stormwater shall be prevented from becoming a pollutant source for storm water discharges by removing potential pollutants, by dikes or barriers or by other approved methods.

Interim stabilization practices shall include silt fence, filter barriers, check dams dewatering basins, sediment traps, soil stabilization mats and erosion control mulch as shown on the Plans and covered in the Specifications. Permanent stabilization practices shall include seeding and establishment of vegetation as shown on the Plans and covered in the Specifications.

Sanitary facilities (including portable toilets) shall meet all requirements of the State and local Board of Health and shall be located and maintained to avoid any discharge into the adjacent waterways. Storage areas for construction materials, construction debris and salvaged materials shall be located as shown on the plans. Measures (such as filter fence, dikes, geotextiles, etc.) to prevent pollutants from entering waterways shall be installed where appropriate. Vehicle fueling areas shall be located with appropriate dikes or geotextile barriers to prevent spills from entering waterways.

PART 3 - EXECUTION

3.1 EROSION CONTROL

- A.** CONTRACTOR shall control erosion by planning and scheduling construction operations carefully.
- B.** CONTRACTOR shall construct the permanent drainage structures as soon as possible during the progress of the grading work. CONTRACTOR shall coordinate erosion and sedimentation control measures with the final system so as to achieve an economical, continuous and effective erosion and sedimentation control program.
- C.** Methods and measures of erosion control shall be applied to erodible materials exposed during the progress of the work. Erodible areas where work has been suspended shall be stabilized to protect against erosion until the final erosion control methods and measures have been applied.
- D.** Methods and measures shall include, but not be limited to, berms, dikes, dams, sediment basins, sediment traps, filters, fiber mats, netting, gravel or crushed stone, mulch, grass, slope drains, seeding, etc.

- E. Unless otherwise provided, all roadbed slopes shall be prepared, fertilized, seeded and mulched to produce a stand of erosion protection grass of an annual variety. In addition to permanent seeding and mulching, the contractor will be required to protect temporary or intermediate slopes within 30 days or time period required by the Environmental permitting of exposing the earth, as designated by the ENGINEER, from erosion by temporary seeding or as required by the environmental permitting.
- F. All work and materials shall be in accordance with the applicable Specifications of the local State Department of Transportation, for the soil, the area and the planting season. The CONTRACTOR shall confer with the proper Department of Transportation authority on the subject and shall follow its recommendations.
- G. The Contractor shall be responsible for the proper maintenance of the seeded areas during the period when the grass is being established and providing a satisfactory cover. The maintenance of grass shall begin immediately upon completion of any portion of the grassing and shall extend until the desired cover is established. A satisfactory stand is defined as a cover of living grass in which gaps larger than 18 inches in diameter do not occur at the time of acceptance by the ENGINEER.

3.2 DUST CONTROL

- A. CONTRACTOR shall pay for and apply all the necessary methods to control dust on the job site. Dust control is applicable in all areas of excavation, roadways (temporary and permanent) and all other areas within the limits of the work.
- B. CONTRACTOR will be held responsible for all suits or damage arising from dust.
- C. Execution: CONTRACTOR shall control dust by sprinkling all dust prone surfaces with water or suitable chemicals and in compliance with all local ordinances.
- D. CONTRACTOR will be required to maintain all haul roads, permanent access roads, and all other work areas within or without the project boundaries free from dust which would cause the standards for air pollution applicable to the project area to be exceeded or which would cause a hazard or nuisance to others. Approved temporary methods of stabilization consisting of sprinkling, chemical treatment or similar methods will be permitted to control dust. Sprinkling, to be approved, must be repeated at such intervals as to keep all parts of the disturbed area at least damp at all times, and CONTRACTOR must have sufficient competent equipment on the job to accomplish this if sprinkling is used. Dust control shall be performed as the work proceeds and whenever a dust nuisance or hazard occurs. No separate or direct payment will be made for dust control, and the cost thereof shall be considered incidental to and included in the contract prices for excavation and embankments.

3.3 ENVIRONMENTAL PROTECTION

- A. The work covered under this subsection consists of furnishing all labor, materials and equipment and performing all work required for the prevention of environmental pollution during and as a result of construction operations under the contract. For the purpose of this specification, environmental pollution is defined as the presence of chemical, physical or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balance of importance to human life; affect other species of importance to man; or degrade the utility of the environment for aesthetic and recreational purposes. The control of environmental pollution requires consideration of air, water and land, and involves noise, solid waste management and management of radiant energy and radioactive materials, as well as other pollutants.
- B. In order to prevent and to provide for abatement and control of all environmental pollution arising from the construction activities of CONTRACTOR, CONTRACTOR shall comply with all applicable federal, state and local law, and regulations concerning environmental pollution control and abatement, and all applicable provisions of the Corps of Engineers' manual, EM 385-1-1, entitled General Safety Requirements, in effect on the date of solicitation, as well as the specific requirements stated elsewhere in the contract specifications.

- C. ENGINEER will notify CONTRACTOR in writing of all non-compliance with the foregoing provisions and the action to be taken. CONTRACTOR shall, after receipt of such notice, immediately take corrective action. Such notice, when delivered to CONTRACTOR or its authorized representative at the site of the work, shall be deemed sufficient for the purpose. If CONTRACTOR fails or refuses to comply promptly, ENGINEER may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to any such stop orders shall be made subject of a claim for extension of time or for excess costs or damages by CONTRACTOR unless it was later determined that CONTRACTOR was in compliance.
- D. Compliance with the provisions of this section by subcontractors shall be the responsibility of CONTRACTOR.
- E. Prior to commencement of the work, CONTRACTOR will:
1. Submit in writing its proposals for implementing this section for environmental pollution control.
 2. Meet with ENGINEER to develop mutual understandings relative to compliance with this provision and administration of the environmental pollution control program.
- F. Location of Construction Facilities: The location on company property of CONTRACTOR's storage and other construction buildings, required temporarily in the performance of the work, shall require written approval of ENGINEER. The preservation of the landscape shall be an imperative consideration in the selection of the site and in the construction of buildings. Plans showing storage and other construction facilities shall be submitted for the approval of ENGINEER.
- G. Protection of water resources:
1. CONTRACTOR shall not pollute any waterway with fuel, oils, bitumen, calcium chloride, acids or harmful materials. It is the responsibility of CONTRACTOR to investigate and comply with all applicable federal, state, county and municipal laws concerning pollution of rivers and streams. All work under this contract shall be performed in such a manner that objectionable conditions will not be created in streams through or adjacent to the project area.
 2. At all times of the year, special measures shall be taken to prevent chemicals, fuels, oils, greases, bituminous materials, waste washings, herbicides and insecticides, and cement and surface drainage from entering public waters.
 3. Disposal of all materials, wastes, effluents, trash, garbage, oil, grease, chemicals, etc., in areas adjacent to streams shall be subject to all Federal, state and local guidelines. If any waste material is dumped in unauthorized areas, CONTRACTOR shall remove the material and restore the area to the condition of the adjacent undisturbed area. If necessary, contaminated ground shall be excavated, disposed and replaced with suitable fill material, compacted and finished with topsoil, all at the expense of CONTRACTOR.

3.4 CETIFICATION REQUIREMENTS

The Contractor shall apply for and obtain the VPDES Construction Permit. Permit Registration Statement shall be sent to:

DEQ Northern Regional Office
13901 Crown Court
Woodbridge, VA 22193
(703) 583-3800

3.5 OFF SITE REQUIREMENTS

The Contractor and/or Subcontractor shall develop erosion and sediment control plan(s) and stormwater management plan(s) for submission and acceptance by VRE and CSXT prior to usage of any support facilities, off-site borrow and disposal areas,

construction materials or equipment storage areas, and other industrial stormwater discharge directly related to the construction process. Such plans, upon acceptance, will become a part of and subject to the overall project plan, VPDES Construction Permit, and contract requirements.

3.6 REPORTING PROCEDURES

A. Inspection Requirements

The Contractor and/or Subcontractor are responsible for conducting inspections in accordance with the requirements of Section 107.14(a) of the VDOT Road and Bridge Specifications and the CSX Erosion and Sediment Control Plan.

A report summarizing the scope of the inspection, name(s) and qualifications of personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of the storm water pollution prevention plan, and actions taken shall be made and retained as a part of the storm water pollution prevention plan. Major observations should include: the location(s) of discharges of sediment or other pollutants for the site; location(s) of settlement basins that need to be maintained; location(s) of settlement basins that failed to operate as designed or proved inadequate for a particular location; and location(s) where additional settlement basins are needed that did not exist at the time of the inspection. Such reports shall identify any incidents of noncompliance. Where a report does not identify any incidents of noncompliance, the report shall contain a certification that the facility is in compliance with the storm water pollution prevention plan and permit.

B. Unauthorized Discharge Requirements

The Contractor and/or Subcontractor shall not discharge into state waters sewage, industrial wastes, other wastes, or any noxious or deleterious substances or otherwise alter the physical, or biological properties of state waters and make them detrimental to the public health, animal or aquatic life, the use of such waters for domestic or industrial consumption, for recreation, or for other uses.

Notification of discharges or non-compliance

The Contractor and/or Subcontractor shall quickly notify the Engineer upon discovery of or potential of any unauthorized, unusual, extraordinary, or non-compliant discharge from the construction activity, but in any case not later than 24 hours after said discovery.

Detailed report requirements for discharges and non-compliance

The Contractor and/or Subcontractor shall submit to the Engineer within 5 days of the discovery of the discharge a written report describing the details of the discharge to include its volume, location, cause, and any apparent or potential effects on private and/or public properties or endangerment to public health, as well as steps being taken to eliminate the discharge.

C. Plan Changes/Deficiencies

The Contractor and/or Subcontractor shall report to the Engineer when any planned physical alterations or additions are made to the construction activity or deficiencies in the project plans or contract documents are discovered that could significantly change the nature or increase the quantity of the stormwater pollutants discharged from the construction activity.

END OF SECTION 020115



PART 1 - GENERAL

1.1 DESCRIPTION

- A. The work includes furnishing and placing erosion control matting (blankets), all plant, labor, and equipment and performing all operations required for supplying, hauling and placing the matting, complete, at locations shown on the plans or as directed by ENGINEER, and maintaining the matting until seeding has been completed and accepted.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for the pay item, EROSION CONTROL MATTING, shall be in the unit of square yards for the areas actually covered by matting, as shown on the plans, and authorized by the ENGINEER. The method of measurement will not include areas where an overlaps of material have occurred twice.
- B. Payment for this item at the unit price bid shall be full compensation for supplying all labor, material, equipment, tools, and all other items of expense to furnish and install the erosion control matting.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The plans will specify the type, thickness, and material composition of the erosion control matting. Generally, one of the following types will be specified:
 - 1. Curlex is a wood machined mat of curled wood excelsior. Both top and bottom of each blanket shall be covered with a photo degradable, extruded plastic mesh.
 - 2. Jute mesh is a 100% biodegradable woven erosion control blanket.
 - 3. Straw blankets are made from 100% agricultural straw, stitched with photo degradable polypropylene thread or stitched to jute netting.
 - 4. Turf blankets are made of polypropylene, coconut matrix materials, or other plastic materials.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Before installing the erosion mat furnish the Engineer two copies of the manufacturer information for the product including installation instructions.
- B. Install erosion mat of uniform thickness on the prepared soil surface in accordance with these Specifications, the manufacturer's recommendations and in conformity with the lines, grades and dimensions as shown in the plans.
- C. Ensure that all joints are shingle lapped such that the bottom of each section fits over the top of the section below to prevent uplift of the ends or edges by water flow. Overlap ends of adjacent edges at 3 to 5 feet intervals with staples as recommended by the manufacturer unless otherwise plans and the manufacturer's installation recommendations.
- D. Ensure that after installation there are no protrusions, projections or exposures of the plastic erosion mat. Do not compact the installed erosion mat with any type of equipment employing a foot or grid.

- E.** The Engineer will reject any material having defects, tears, punctures, flaws, deteriorations or other damage before, during or after installation. Remove and replace all rejected erosion mat at no additional expense³ to the Railroads.
- F.** Fill all voids in the mat with soils that will enable the establishment of the stand of grass required.

END OF SECTION 020120



PART 1 - GENERAL

1.1 DESCRIPTION

- A. The work shall consist of furnishing all plant, material, labor, and equipment and performing all operations required for supplying, hauling and placing the filter fabric, complete, at locations shown on the plans or as directed by ENGINEER, and maintaining until placement of the filter material has been completed and accepted.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the pay item, SILT FENCE, shall be by the linear feet actually installed and removed and as directed by the ENGINEER.
- B. Payment for the item SILT FENCE at the unit price bid shall be full compensation for supplying all labor, material, equipment, tools, supplies and all else necessary to furnish, install, maintain, inspect and remove the silt fence.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The filter fabric shall be governed by the local State's Department of Transportation material specifications.

PART 3 - EXECUTION

3.1 EXECUTION

- A. The fabric shall be protected from excessive sunlight, ultra-violet light, high temperatures, dirt and debris at all times prior to its installation.
- B. The filter fabric shall be placed at the locations shown on the plans or as directed by ENGINEER.
- C. The surface to receive the fabric shall be prepared to a relatively smooth condition, free of obstructions, depressions, debris, and soft or low density pockets of material.
- D. The fabric shall be laid smooth and free of tension, stress, folds, wrinkles and creases.
- E. When securing pins are necessary in the placement of the fabric, the pins shall be 3/16 inch diameter steel, pointed at one end, and twenty-two inches long.
- F. All damage to the fabric during its installation or during placement of the backfill shall be replaced or repaired by CONTRACTOR at no expense to the railroad. All holes, rips, or flaws made in the fabric shall be replaced with a new section of fabric.
- G. Where fabric is to be used in the construction of brush barriers, the fabric shall be laid over the fill slope face of the barrier. The bottom of the fabric shall be trenched into the existing ground a minimum of six (6) inches. The top of the fabric shall be tied, stapled, nailed or otherwise securely fastened to the side or top of the brush barrier. Intermediate attachment of the fabric shall be by suitable ties, staples or nails. An 18 inch overlap of fabric for vertical and horizontal piecing shall be maintained. Care must be exercised in securing the fabric to the brush barrier to avoid puncturing by protruding limbs.

- H. Posts will be spaced 6-10 feet apart depending on the amount of flow expected. Posts will be installed with a minimum of 2 feet in the ground. Filter fabric will be attached to the wire fence or post by wire, cord or staples. The filter fabric will be installed in such a manner that 4 to 6 inches of fabric is left at the bottom to be buried and a minimum overlap of 18 inches is provided at all splices.
- I. The CONTRACTOR shall maintain the silt fence until the fence is removed, and shall remove and dispose of silt accumulations at the silt fence when so directed by the ENGINEER. Filter fabric shall be removed and replaced whenever it has deteriorated to such extent that it reduces the effectiveness of the silt fence.
- J. Silt fence shall remain in place unless the ENGINEER directs that it be removed. Silt fence which has been removed will remain the property of the CONTRACTOR and may be used at other locations provided it is in a condition acceptable to the ENGINEER. Upon removal of the silt fence, the CONTRACTOR shall dress the area to give a pleasing appearance, and shall seed and mulch the area in accordance with these specifications.

END OF SECTION 020130



PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall install in place or relocate, as necessary, all new and existing signage as directed by the ENGINEER in conjunction with the new construction. Signage shall include, Close Clearance Signs, Train Horn/Whistle Signs, Milepost and Numeral Signs, and Private Crossing Signs.

1.2 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment shall be included for signage all work under this item shall be incidental to the Mobilization/Demobilization pay item.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. CSXT to provide all material for signage if not available for relocation.
- B. Close Clearance Sign material shall be in accordance with CSXT Standard Drawing 2707, latest revision
- C. Train Horn/Whistle Sign material shall be in accordance with CSXT Standard Drawing 2708, latest revision
- D. Permanent Speed Restriction Sign material shall be in accordance with CSXT Standard Drawing 2709, latest revision
- E. Milepost and Numeral Signs material shall be in accordance with CSXT Standard Drawing 2710, latest revision
- F. Critical Clearance Sign material shall be in accordance with CSXT Standard Drawing 2727, latest revision.
- G. Private Crossing Sign material shall be in accordance with CSXT Standard Drawing 2729, latest revision

PART 3 – EXECUTION

3.1 EXECUTION

- A. CSXT to provide all material for new signage, CONTRACTOR to assemble and install. For existing signs to be relocated, CONTRACTOR to remove and reinstall. Locations to be directed by CSX Engineer.
- B. Close Clearance Sign installation shall in accordance with CSXT Standard Drawing 2707, latest revision
- C. Train Horn/Whistle Sign installation shall in accordance with CSXT Standard Drawing 2708, latest revision
- D. Permanent Speed Restriction Sign installation shall in accordance with CSXT Standard Drawing 2709, latest revision
- E. Milepost and Numeral Signs installation shall in accordance with CSXT Standard Drawing 2710, latest revision
- F. Private Crossing Sign installation shall in accordance with CSXT Standard Drawing 2729, latest revision

- G.** Existing and previously erected signs in use by the railroad shall only be relocated after coordination with the CSX ENGINEER. Care shall be taken to relocate signs in a precise and perpendicular to the track(s) they govern and shall be relocated without damage or replaced with new signs in accordance with CSX specifications.

END OF SECTION 020135



PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section includes: topsoil stripping; excavating; removing abandoned pipelines and other abandoned structures; replacing unsuitable soils; placing embankment; and disposal of earthen materials on or off site.
- B. The grading and placement of suitable material that establishes the new compacted subgrade shall be to the lines and grades indicated on the drawings. Work shall be done in accordance with the following provisions:
1. Grading -The term "Grading" used in these Specifications covers moving of earth, rock and all other material from cuts, borrow pits, ditches, and channels for waterways, constructing embankments, protecting slopes paving ditches, gutters and channels for waterways, water pollution, soil erosion, siltation control, and all similar work connected with and appertaining to, or necessary for, the construction of main tracks, yard tracks, side tracks, spur tracks, station grounds and specialized terminals, etc.
 2. Right of Way - RAILROAD will furnish a right-of-way of sufficient width for the project.
 3. Lines, Grade and Cross-sections - All excavations and embankments shall be constructed to the lines, grades, cross-sections, slopes and dimensions called for on contract drawings, or to such modifications or revisions thereof as may be directed in writing by ENGINEER.
 4. Sub-surface Conditions - It is the obligation of the CONTRACTOR to make his own investigations of subsoil condition prior to submitting his Proposal. Borings, test excavations and other subsoil investigations, if any, made by ENGINEER prior to the construction of the project, and the records of which are shown on the Plans, are made for design purposes. RAILROAD assumes no responsibility for the correctness of the information nor for the actual subsoil of other conditions which may be found to exist during the progress of construction.
 5. Overhaul - No allowance will be made for overhaul. Payment for transportation of all excavated material shall be included in the unit prices bid for the various items generally grouped as EARTHWORK in the Proposal.
 6. Temporary Crossing of Railroad Tracks - When CONTRACTOR desires a temporary road crossing of operated railroad tracks and it is considered necessary in the judgment of ENGINEER, the locations and construction of crossing shall be subject to approval by ENGINEER, and all of its requirements shall be fully met. When a crossing is necessary to transport material across the track or tracks, the location and construction of the crossing must be approved by the ENGINEER. Crossings installed over tracks which are owned by RAILROAD shall be installed and removed by RAILROAD forces. Crossings over tracks not owned by RAILROAD shall be installed and removed by the CONTRACTOR. The cost of all temporary crossings whether by RAILROAD or the CONTRACTOR shall be the responsibility of the CONTRACTOR.

The crossing shall be maintained and protected to the satisfaction of RAILROAD. The entire cost of construction, maintenance, protection and removal of Temporary Crossings required by CONTRACTOR shall be included in the prices bid for the scheduled items except for the portion of work done by Railroad forces on crossings shown on the Plans. Where crossings of operated railroad tracks are shown on the Plans, RAILROAD will provide railroad traffic protection at CONTRACTOR's expense.
 7. Slopes of cuts, ditches, channels and embankments shall be constructed and dressed to the lines prescribed on the Plans or in the Supplement Specifications. Variations may be required to suit local conditions encountered, but no variation shall be made unless directed or approved by ENGINEER in writing.

8. Slope construction shall include excavation and dressing all terraces, berms, berm ditches, ditches at top and bottom of slopes, and gutters on terraces.
9. CONTRACTOR shall follow all local and state "Call Before You Dig" laws.

C. UNCLASSIFIED EXCAVATION

This work shall consist of excavation for all railroad facility subgrades and channels, including the removal of all material encountered not being removed under some other items, disposing of all material excavated whether or not used as fill, and finishing shoulders, slopes and ditches.

1. No classification of the kinds of material encountered in excavation will be made.
2. Disposal of Excavated Material – All suitable materials excavated within the limits of the project shall be used as embankment (fill for roadbed and/or slopes). For detail on suitable material see section F. Where the quantity of excavation exceeds that required to make up embankments to cross-section as shown on the Plans, the suitable surplus material shall be used to widen embankments (roadbed and/or slopes) uniformly along one or both sides, when directed by ENGINEER.
3. Waste areas, for the disposal of excess material unable to use as widen roadbed or unsuitable material, will be disposed of as shown on the Plans. With approval of the ENGINEER in writing an alternative site where as such materials deposited in a manner as will not endanger the roadway maybe requested. The clearing and seeding of the waste site will be included in the unit price for excavation unless otherwise specified.
4. Over Excavation - The toe of slopes in excavation shall in no case be undercut by power shovels, bulldozers, graders, blasting, or in any manner. Excavation shall not be made in excess of the authorized cross-section and such excess excavation will not be included in the measurements for payment. Where slides occur and extend beyond the slope lines, CONTRACTOR will not be paid for the removal of such material unless in the judgment of ENGINEER they are due to causes which are not the fault of CONTRACTOR. In all cases the surplus material shall be removed by CONTRACTOR and the slopes formed to the satisfaction of ENGINEER.
5. Removal of Miscellaneous Materials - The excavation, removal and disposal of minor pavements, timber or concrete foundations, not apparent on the surface or subsurface, rock, boulders, encompassing a volume of less than one cubic yard and all other subsurface materials encountered shall be considered as UNCLASSIFIED EXCAVATION, except as covered under other sections in the specification. Such materials shall be removed to an elevation six inches below final sub-grade as designated on the cross sections within ten (10) feet of the centerline of any proposed track or within five (5) feet of the edge of any roadway. In other areas, all such materials shall be removed to the elevation of final grade.
6. Roadbed Excavation - Roadbed Excavation shall include the excavation to the prescribed lines, grades, and cross-sections, and the removal and satisfactory disposal of all earth, rock, boulders, masonry and all other materials encountered, of whatsoever nature, required for the construction of main tracks, yard tracks, side tracks, spur tracks, station grounds, specialized terminals and similar appurtenant work, construction of embankments of the excavated material in accordance with provisions as specified herein and ditching and channel excavation when these items are not scheduled in the Proposal.
7. Channel Excavation - Channel Excavation shall include the excavation to the prescribed lines, grades and cross-section, and the removal and satisfactory disposal of all materials encountered of whatsoever nature, required for deepening, widening and relocating water channels.
8. Ditch Excavation - Ditch Excavation shall include the excavation to the prescribed lines, grades and cross section, and the removal and satisfactory disposal of all materials encountered of whatsoever nature, required for constructing ditches.
9. Where wet cuts are encountered, the roadbed will be constructed extra wide with ditches of extra depth and width as shown on "Section At Wet Cuts" on current RAILROAD standard drawing 2601, latest revision.

10. Intercepting and berm ditches shall be provided at the top of the cut slopes and the toe of the embankment slopes to divert storm water, which flows toward the roadbed. Roadbed ditches shall be provided as indicated with the outfall ends diverging sufficiently to prevent erosion of the adjoining embankments. All ditches shall be in accordance with RAILROAD Standard Roadbed Section or as approved by the ENGINEER.
11. Should unsuitable material be encountered such as muck, highly plastic clays or silty unstable material, it shall be removed at the direction of the ENGINEER. Unsuitable materials are handled per standard specification 020240, **Unsuitable Soils**.

D. EMBANKMENTS

Embankment construction shall consist of placing and compacting suitable materials in embankment at the required locations to the prescribed lines, grades, cross-sections, and dimensions shown on Plans and as directed or approved for wasting of surplus acceptable material to widen embankments. The CONTRACTOR shall construct embankments to such heights above subgrade and to such increased widths as are necessary to provide for shrinkage, subsidence, and erosion. As the embankments become consolidated, their sides shall be trimmed to the proper dimensions and shapes until the completion and acceptance of the work.

1. Materials used for embankment shall be suitable inorganic soil, granular material, rock or random materials and shall be free from stumps, wood, brush, leaves, roots, sod, rubbish, debris, garbage, frozen material, inflammable material, or any perishable matter. Any materials subject to degradation by weathering, or cinders, will not be acceptable. Suitable material will be as defined herein.
2. The materials used in embankment shall be those available from the various items of Earthwork, or other suitable material delivered by RAILROAD in cars or RAILROAD approved materials brought to the project by CONTRACTOR.
3. Before placing embankment material, the underlying ground surfaces shall be prepared between bottom of slope stakes as provided in CLEARING & GRUBBING AND TOPSOIL STRIPPING, as specified herein, and shall be free of snow and ice. Embankment material shall not be placed on frozen material of either the embankment or foundation.
4. Where the embankment is placed on sloping ground or existing embankments, the existing ground shall be plowed, scarified or benched. The cost of such treatment will be included in the unit price bid for the item UNCLASSIFIED EXCAVATION in the Proposal.

Benching shall be required where slopes are steeper than 8:1 in any direction. The roadbed will be continuously benched over those areas where it is required as the work is brought up in layers. Benching shall be of sufficient width to permit operation of placing and compacting equipment. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous cut. Suitable materials thus cut out, except for topsoil, shall be reused along with the new embankment material.

Where benching is not required, embankment foundation areas, stripped of topsoil, shall be plowed or scarified to a depth of at least eight inches and then compacted as specified herein or by ENGINEER in the field. This requirement can be waived by ENGINEER in inundated, swampy areas or areas where field conditions warrant. The use of filter fabric may be permitted by ENGINEER to permit the operation of construction equipment over the subgrade.

5. Except as hereinafter provided, embankments shall be formed in horizontal layers, with loose lifts placed no deeper than eight inches, extending across the entire fill.

6. The material shall be leveled to a uniform cross-section and shall be thoroughly compacted to the specified density and moisture content before the next layer is started. When necessary to achieve proper compaction, the moisture content of the material shall be altered to bring its moisture content sufficiently close to optimum, as specified herein. The material may be uniformly wetted by the controlled application of water to in place embankment material; or dried by plowing, discing and aerating, which drying process may be carried out either on the embankment or at the source of the material. Other methods shall be proposed by the CONTRACTOR and reviewed by the ENGINEER.
7. When the amount of embankment material required exceeds the amount of suitable material to be excavated within the limits of the grading section, sufficient suitable material, approved by ENGINEER, shall be obtained by CONTRACTOR from borrow pits furnished by CONTRACTOR located outside of RAILROAD property, except when permission is given, in writing, by ENGINEER to use a borrow pit which may be available on RAILROAD property or permission is given by ENGINEER to widen the roadway excavation to obtain additional material.
8. All topsoil, sod, brush, weeds, roots, and other unsuitable material shall be removed from the surface of borrow pit prior to the removal of any materials. All borrow materials will be measured for payment in place in the embankment. The cost of such removal shall be included in the price bid for Off Site Borrow Material.
9. Trucks, cars or other equipment used for transporting material from borrow pits shall have tight bodies and shall be loaded and covered so that no material will be lost while in transit.
10. The source and quality of borrow material shall be approved by ENGINEER and comply with CSX's EMPA guidelines in section 020215, **Excess Material Placement Area (EMPA)** before excavation of such borrow is made. The CONTRACTOR may be required to obtain at his sole expense, property for borrow from sites other than RAILROAD owned property. Prior to the use of the property, the CONTRACTOR will secure from the owner a written permit or agreement satisfactory to the ENGINEER, for the use of the property.

Borrow pits will be seeded and mulched as required by permit and unless otherwise specified, clearing, seeding and mulching costs will be included in the unit price for Off Site Borrow Material.
12. If directed by ENGINEER, borrow pits on RAILROAD property shall be connected with ditches and drained to the nearest water course and no material shall be borrowed from a depth that will not permit proper drainage without the approval of ENGINEER. CONTRACTOR shall provide immediate, permanent, or temporary control measures to prevent contamination of adjacent streams or other water courses, lakes, ponds, or other areas of water impoundment. Such work may involve the construction of temporary benches, dikes, dams, sediment basins, slope drains, and the use of temporary mulches, mats, seeding or other control devices or methods necessary to control erosion, as required by Federal, State or local authorities. All borrow pits shall be left in a neat condition. Side slopes on borrow pits on RAILROAD property or adjacent thereto shall be the same as used in the cross-sections of embankments of roadbed. Final condition of all borrow pits must be approved by ENGINEER.
13. A berm of the original unbroken ground not less than ten feet (10) in width shall be left between slope stakes of embankment and edge of borrow pits and a similar berm between outside slope of borrow pits and RAILROAD right-of-way unless otherwise shown on the Plans or approved in writing by ENGINEER.

E. OFF SITE BORROW EXCAVATION

1. Off Site Borrow Material shall include excavation, removal and satisfactory disposal of all material from borrow pits, construction of embankments of the excavated material in accordance with the provisions as specified herein and preparing subgrade in accordance with the provision as specified herein. Refer to section 020235, **Off Site Borrow Material**.

F. EMBANKMENT SOIL AND COMPACTION

1. Soil shall include all durable inorganic earth materials having a maximum particle size of three inches (as determined by current ASTM Designation D 422); a plasticity index between 0 and 35 (as determined by current ASTM Designation D 422); and that can be readily placed and compacted to the required density in loose 8-inch layers.

Organic soils will not be permitted for use in embankment construction. Fine grained soils which are moisture sensitive may be placed and compacted only during periods of dry weather. Where such soils are used and become wetted, due to natural causes or by fault of CONTRACTOR or by accident, to the extent they exhibit rutting and/or weaving characteristics, when subject to construction traffic, they shall either be removed and replaced with suitable materials or dried as specified herein, as directed by ENGINEER.

Any such materials removed may be stockpiled and dried to the required moisture content for later placement and compaction. All soil which is placed on embankment foundation to a plane three feet below the subgrade plane, and to the Plan slope limits shall be compacted to at least 95% of its maximum density and within 2% of its optimum moisture content as determined by current ASTM Designation D 1557, Modified Proctor.

All soil placed from subgrade plane and to a plane three feet below the subgrade plane, shall have less than 20% passing a #200 sieve (as determined by current ASTM Designation D 1140) and shall be compacted to at least 100% of its maximum density or to a relative density of 75% of its maximum, whichever is higher, as determined respectively by current ASTM Designation D 1557 or current ASTM Designation D 2049.

The in-place density of compacted embankment soils will be determined either by current ASTM Designation D 1556 (Sand Cone Method) or D 2167 (Balloon Method) or D-2922 (Nuclear Method). Any soil layer placed in the embankment and found deficient in required density shall either be brought to specification requirements or removed, as directed by ENGINEER, prior to placing and compacting any subsequent layers.

2. Shale shall include all rock-like materials formed by the natural consolidation of mud, clay, silt and fine sand. Useable shale shall be thinly laminated, comparatively soft and easily split, having a maximum size that can be readily placed and compacted in loose 8-inch layers.

Shale which consists predominately of fine particles which can be readily tested for compaction in the laboratory and field shall be placed and compacted in accordance with requirements for soil. Shale containing sufficient amounts of large particles to make checking of the compaction impractical shall not be used within design embankment slope limits. When approved by ENGINEER, such materials may be used to flatten embankment slopes under ten feet in height, if approved by ENGINEER.

No embankment flattening shall be done with this material until such time as approval is granted. Shale that is or becomes unstable in the presence of air and water shall not be used for embankment construction.

3. Rock, other than shale, shall include all igneous, metamorphic, and sedimentary rock which cannot be excavated without blasting or by the use of rippers and all boulders and detached stones having a maximum size that cannot be readily placed and compacted in loose 8-inch layers. The use of any micaceous rock or rock containing degradable sulphur minerals or asbestos will not be permitted.

Rock shall be placed in uniform loose layers not exceeding in thickness the approximate average size of the larger rock, but limited to a maximum thickness of two feet. Oversize rock shall be reduced in size until it can readily be incorporated into a 2-foot layer. All voids shall be filled by brooming in with spalls and other acceptable filling material and thoroughly wetted and compacted until an unyielding layer is formed.

Rock shall not be placed against the back slope of side hill fills nor shall an existing embankment be benched for the placement of a rock embankment or rock slope. The top three feet of an embankment must not be made up of rock fill. The compaction program for rock shall be submitted to ENGINEER for approval. No

embankment shall be built until such time as approval is granted.

When rock or other embankment material are excavated at approximately the same time, the rock shall be incorporated into the other slopes of the embankment to a 1 on 1 plane extending from the intersection of the design slope and subgrade plane from natural ground to a line three feet below the subgrade plane. The inner portion of the embankment adjacent to rock fill shall be held at substantially the same elevation as the rock fill, but always above the rock fill at a height sufficient to avoid incorporating water used to wet the rock fill in such quantities as to cause rutting or weaving of the inner embankment fill under the operations of construction equipment.

4. The top three feet of all embankments shall be formed of granular material or soil, as required herein. Provisions should be made to reserve this material from excavation where available. Should such materials be available and not reserved, it shall be furnished and placed by CONTRACTOR at his expense. In the event granular material or soil having less than 20% passing a #200 sieve is not available on-site, this layer shall be paid for at the unit price in the proposal for OFF SITE BORROW MATERIAL.
5. Embankment material placed in areas inaccessible to compaction equipment used to form the main body of the embankment shall be placed in uniform loose layers not exceeding four inches and be compacted by means of approved mechanical or vibrating compacting equipment to the density requirements specified herein.
6. Where embankment is to be constructed across low swampy ground, open water, or other areas which will not support the weight of trucks or other hauling equipment, dumping of suitable materials, as approved by ENGINEER, shall be used to such an elevation only that will permit the use of compacting equipment and the remainder shall be constructed in layers to conformity with these Specifications or as shown on the Plans. In no case shall end dumping be started until ENGINEER has approved the surface on which embankment is to be constructed.
7. Where end dumping is necessary, the material shall be deposited so that the soft underlying material will be forced to the sides and not to the front of the areas filled. End dumped material shall be properly compacted in a manner satisfactory to ENGINEER.
8. Embankment, other than rock embankment, in areas back of bridge abutments and in areas adjacent to structures under embankments, other than pipe structures, shall be formed of free-draining soil having a maximum size of three inches, and shall be constructed in advance of other embankment sections. Back of bridge abutments, this area shall extend longitudinally for a distance of twice the height of the embankment above the top of the footing or above the natural ground line, if such ground line is above the top of the footing.

Adjacent to structures under embankment, the soil shall be placed to the height of the structure and in the adjacent area longitudinally for a distance of twice the height of the structure. Shale, rock or plastic soils shall not be used in bridge abutment backfill construction. When filling behind abutments and similar structures, all material shall be placed so that fill height on one side of a wall is never greater than two feet above the material on the other side or as shown on the Plans. The materials shall be deposited in layers of not more than six inches in thickness, carefully tamped and sloped away from the structure.

Filling over arches, boxes and large pipes shall be deposited uniformly on both sides. Large stones shall not be placed within two (2) feet of the exterior surface of any arch, top and sides of boxes, or outside of large pipes. Any damage to waterproofing shall be repaired by the CONTRACTOR at his sole cost and expense.

In forming embankments from or about trestles, the material shall be spread uniformly, without depressions between slopes and shall be thoroughly compacted between the trestle bents and around and under all parts of the structure. No part of the trestle shall be left in the embankment with three (3) feet of the sub-grade. Construction trestles for the formation of embankment will not be permitted unless approved by the ENGINEER.

9. CONTRACTOR shall be responsible, until acceptance by RAILROAD, for stability of all existing and new embankments constructed and shall replace all sections which, in the opinion of ENGINEER, have been damaged or displaced due to carelessness or neglect on the part of CONTRACTOR, or due to natural causes, such as storms, etc.

Acceptance will not be given until all required slope protection, i.e., seeding or sodding, etc., is completed.

10. At the close of each day's work, the entire working area shall be graded to drain.
11. At the beginning of each day's work, the embankment should be restored to such a condition that the specifications as herein stated are met. Any changes in moisture content, shape, and density due to natural causes shall be repaired at CONTRACTOR's expense prior to the start of the work of the day. Any frozen soil materials shall be completely removed and wasted on embankment side slopes or as directed by ENGINEER.
12. Fill or backfill material at structures, culverts, pipes, conduit, and direct burial cable shall conform to the quality requirements herein unless otherwise stated herein, or as shown on the Plans. All such material shall be placed in uniform horizontal loose lifts not exceeding six inches and be compacted to 95% of its maximum density and not to exceed 2% of its optimum moisture as determined by current ASTM Designation D1557 (Modified Proctor) or as shown on the Plans. Compaction shall be by means of approved mechanical or vibratory compacting equipment.
13. CONTRACTOR shall be responsible for proper placement and compaction of all materials in the railroad embankment, and for correcting any deficiencies resulting from insufficient or improper compaction and moisture control of such materials throughout the contract period. CONTRACTOR shall provide the type size and weight of compactor best suited to the work at hand; exert proper control over the moisture content of the material, and other details necessary to obtain satisfactory results.
14. Rutting or weaving of a compacted layer under the section of construction equipment shall not necessarily be interpreted as due to faulty compaction or moisture control during compaction, but shall be considered as constituting damage to a compacted lift requiring full repair prior to placing any overlying materials. ENGINEER will prohibit placement of an overlying lift until CONTRACTOR takes effective corrective action.
15. The selection of compaction equipment needed to meet the requirements specified herein is CONTRACTOR's responsibility but shall be subject to approval by ENGINEER. Any equipment not principally manufactured for compaction purposes and equipment which is not in proper working order shall not be approved or used. ENGINEER will also withhold approval of any compactor for which CONTRACTOR cannot furnish manufacturer's specifications covering data not obvious from a visual inspection and necessary to determine its classification. The use of tractors, trucks, scrapers or other equipment designed for purposes other than solely compaction will not be considered as compaction equipment.
16. Sufficient leveling and compacting equipment shall be provided to do the work of spreading and compacting the material promptly after it has been deposited. When, solely in ENGINEER's judgment, such equipment is inadequate to spread and compact the material properly, CONTRACTOR shall reduce the rate of excavation placing of fill to a rate not to exceed the capacity of leveling and compacting equipment or employ additional equipment.
17. CONTRACTOR shall make sufficient passes of the compacting equipment over each loose lift of material to obtain the specified densities. The compacting equipment shall be operated in a systematic manner so that the number of coverage's over all areas can be readily determined and recorded. One pass shall be defined as the complete application of the compaction equipment's rated energy over the entire area to be compacted.

G. SUBGRADE PREPARATION

The bottom of sub ballast for railroad roadbed shall be known as the subgrade and shall be prepared in conformity with the lines as shown on the Plans. Refer to section 020405, **Railroad Subballast**.

1. CONTRACTOR shall prepare the subgrade by proof-rolling to ascertain the uniformity of compaction beneath the subgrade surface, to locate deficiencies requiring correction, and to establish that corrective work has been effective, all immediately prior to final trimming of the subgrade surface and to the placement of sub ballast.
2. Proof-rolling of subgrade surface will not be required where the subgrade surface is rock cut; where, in the opinion of ENGINEER, proof-rolling would be detrimental to the work; where the proof-roller will approach a culvert, pipe or other conduit closer than five feet in any direction; or where the proof-roller may damage adjacent work due to restrictions in available access and for maneuvering space.
3. The proof-roller shall consist of a loaded off-road dump truck weighing approximately 20 tons or similar. Any deviations to equipment must be supported by geotechnical recommendations and must be approved by ENGINEER.
4. Within the ranges set forth herein before, the load and tire inflation pressure shall be adjusted as required. It is the intent of these Specifications to use a contact pressure as nearly practical to the maximum supporting value of the subgrade. The subgrade shall then be rolled with one or more coverage's of the heavy pneumatic-tired roller, as directed by ENGINEER. One coverage shall be considered to represent two trips of the roller, each trip offset from the other by the width of one tire, to obtain complete area coverage. The equipment shall be operated at the speed directed by ENGINEER but in no case shall the speed exceed five miles per hour, and the normal operating speed shall not be less than 2-1/2 miles per hour.
5. When the railroad embankment thickness provides less than three feet of cover over the embankment foundation, the initial stress level shall be based upon the embankment foundation soil and will be set as directed by ENGINEER.
6. Where the operation of the heavy pneumatic-tired roller shows the subgrade to be unstable or to have non-uniform stability, CONTRACTOR shall correct the unstable areas in accordance with the provisions specified herein.

1.2 JOB CONDITIONS

- A. CONTRACTOR shall visit the site and become acquainted with the existing conditions. CONTRACTOR shall accept the site as found prior to submitting the bid to do all excavation as indicated on the plans or as necessary due to existing conditions.
- B. CONTRACTOR shall verify the grades and dimensions shown as existing on the plans. If there are discrepancies between the actual field conditions and those shown on the plans, then CONTRACTOR shall notify ENGINEER and request clarification before continuing with the work.

1.3 MEASUREMENT AND PAYMENT

- A. Measurement of the item UNCLASSIFIED EXCAVATION shall be in units of cubic yards, actually excavated, placed, compacted and authorized by the ENGINEER. Volumes shall be calculated from the original design, and final cross sections. Excavation in excess of the design cross sections shall not be included in the measurements unless ordered by the ENGINEER in writing. Excavation and embankment for temporary access and haul roads or other excavations not specifically shown on the plans will not be included in the measurements. The quantity of excavation shall be calculated by the average end area method.

For measurement of the item OFF SITE BORROW MATERIAL refer to section 020235, **Off Site Borrow Material**.

For measurement of the item SUBBALLAST refer to section 020405, **Railroad Subballast**.

The CONTRACTOR shall arrange for original cross sections to be taken following clearing and grubbing of an area and before beginning excavation or embankment with cross sections data being obtained at even 100 ft. stations as shown on the plans. CONTRACTOR shall provide data and plots of these original cross sections to ENGINEER. The plots will compare CONTRACTOR'S cross sections with the sections shown in the plans. Variances found will be reviewed with the ENGINEER. Excavation and embankment quantities shall be calculated by the CONTRACTOR using CONTRACTOR's original cross sections and plan design cross sections. These quantities must be approved by ENGINEER prior to beginning any earthwork.

The CONTRACTOR shall also arrange for final cross sections to be taken following completion of all earthwork (both excavation and embankment) with cross section data being obtained at even 100 ft. stations as above. CONTRACTOR shall provide data and plots of final cross sections to ENGINEER. Once data and plots are provided CONTRACTOR is to assist ENGINEER with the as-built.

- B.** Payment for the item UNCLASSIFIED EXCAVATION measured as stated above, will be paid at the contract unit price bid. Said unit price bid will be full compensation for furnishing all labor, material, equipment, tools, supplies, accessories and all other items of expense to excavate, store, drain, maintain, cross section, and dispose of materials in accordance with the plans and specifications and section 020215, **Excess Material Placement Area (EMPA)**.

No allowance will be made for overhaul or train caused delays. Payment for transportation of all excavated material shall be included in the price bid for the scheduled excavation in this proposal.

PART 2 - PRODUCTS

2.1 MATERIAL

- A.** Topsoil to be placed for use in seeding areas, including all construction slopes, shall conform to the material requirements of RAILROAD specifications herein.

PART 3 - EXECUTION

3.1 EXECUTION

- A.** No excavation or embankment shall commence until the surface has been cleared and grubbed to the satisfaction of ENGINEER.
- B.** CONTRACTOR shall maintain all working areas in cuts or fills in a well-drained condition.
- C.** If CONTRACTOR excavates below the depth required on the plans without approval of ENGINEER, the area shall be brought back to the designated elevation with embankment borrow, properly compacted, at CONTRACTOR's expense.
- D.** All excavation areas shall be completed as far as is practical before off site borrow materials may be used.
- E.** If pockets of muck, soft clay or any other unsuitable foundation materials are encountered, they shall be excavated to a firm bedding stratum or treated in other manner as described on the plans or as directed by ENGINEER. If any wet excavation is required, it shall be treated similarly. After the excavation, the hole shall be backfilled with granular material and in a manner as described by ENGINEER, to the lines and grades shown on the plans.
- F.** ENGINEER shall determine which material is suitable for fill and which is unsuitable and must be disposed of. Suitable material used for fill shall be placed and compacted in the proposed embankment. Surplus and unsuitable material shall become the property of CONTRACTOR and shall either be removed from the site, or transported to a waste area if ENGINEER designates one.
- G.** Sod and other incidental topsoil removed during stripping shall be stockpiled within the railroad right-of-way as directed by ENGINEER for use on slopes as last placed material for eventual seeding and/or mulching as specified

herein.

- H.** The compaction of the embankment material and subgrade shall be to the limits indicated in RAILROAD specifications herein.
- I.** If a waste area is established on the site CONTRACTOR must grade all waste spoilage areas to grades that ensure against any pockets of water forming.
- J.** If CONTRACTOR encounters subsurface conditions at the site differing materially from those indicated on the plans or such subsurface conditions as could not reasonably have been anticipated by CONTRACTOR and were not anticipated by the RAILROAD, which conditions will materially affect the cost of the work to be done under the contract, the attention of ENGINEER shall be called immediately to such conditions before they are disturbed.
- K.** All active underground utilities shall be braced and shored adequately and shall not be removed. If active piping is to be covered or backfilled, adequate precautions must be taken to prevent damage to the existing service. After the construction has been completed, the active piping shall be left in a condition that will ensure proper function of the service.
- L.** The grading for this project shall be completed to a tolerance of plus or minus one tenth of a foot (0.1 feet) of the elevations indicated on the plans, checked by ENGINEER.
- M.** The locations of all underground utilities, shown on the plans, are approximate and shall be verified for location and depth prior to any grading.

END OF SECTION 020200



PART 1 - GENERAL

1.1 DESCRIPTION

- A. Excavation and embankment areas shall be stripped of topsoil.
- B. Such preparation in fill areas will generally be confined to areas where the fill height is four (4) feet or less or where slopes to receive fill are one (1) vertical to five (5) horizontal or steeper per AREMA recommendations. Also see Section 020110, **Seeding, Mulching, and Soil Supplements**.
- C. Topsoil, which is stockpiled for reuse, shall conform to the following:

1. Reusable topsoil shall be limited to friable loam, reasonably free of subsoil, clay lumps, brush, roots, weeds or other objectionable vegetation, stones or similar objects larger than one inch in any dimension, litter, or other materials unsuitable or harmful to plant growth, and shall not contain less than 5% nor more than 20% organic matter, as determined by current AASHTO Designation T-194.
2. Furnished topsoil shall also meet the following grade analysis:

<u>Sieve</u>	<u>Minimum Percent Passing</u>
2"	100
No. 4	80
No. 10	60

3. Sand, silt, and clay material passing the No. 10 sieve shall be as defined by current AASHTO Designation M 146 and shall be present within the following ranges:

	<u>Minimum Percent</u>	<u>Maximum Percent</u>
Sand	0	75
Silt	10	95
Clay	5	20

1.2 MEASUREMENT AND PAYMENT

- A. Specification included as information only. Measurement for topsoil stripping shall be included as incidental to Section 020200, **Earthwork**.

1.3 REFERENCES

- A. AREMA recommendations

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 EXECUTION

- A.** Stripped material shall be disposed of or stockpiled for reuse as requested by ENGINEER per AREMA recommendations.
- B.** All stripped material shall be disposed of within the railroad right-of-way as designated by ENGINEER.
- C.** Sod and other incidental topsoil removed during stripping shall be stockpiled within the railroad right-of-way for use on slopes as last placed material for eventual seeding and/or mulching.

END OF SECTION 020210



PART 1 - GENERAL

1.1 DESCRIPTION

- A. Excess material generated onsite will be placed in designated excess material placement areas (EMPA) as shown on the plans or directed by the ENGINEER.
- B. Use of this specification does not preclude CONTRACTOR from regulations mandated under Resource Conservation and Recovery Act, or the United States Department of Transportation or other state/federal agencies. CONTRACTOR must obtain and remain in compliance for all required permits during the transport, placement and stabilization of the EMPA.

1.2 MEASUREMENT AND PAYMENT

- A. Specification included as information only. Measurement for the EMPA shall be included as incidental to Section 020200, **Unclassified Excavation**.

The CONTRACTOR shall arrange for original cross sections to be taken following before embankment is placed with cross sections data being obtained at even 100 ft. stations as shown on the plans. CONTRACTOR shall provide data and plots of these original cross sections to ENGINEER. The plots will compare CONTRACTOR'S cross sections with the sections shown in the plans. Variances found will be reviewed with the ENGINEER. Excavation quantities shall be calculated by the CONTRACTOR using CONTRACTOR's original cross sections and plan design cross sections. These quantities must be approved by ENGINEER prior to beginning any earthwork.

The CONTRACTOR shall also arrange for final cross sections to be taken following completion of all earthwork with cross section data being obtained at even 100 ft. stations as above. CONTRACTOR shall provide data and plots of final cross sections to ENGINEER.

- B. No separate payment shall be made for the EMPA. Payment for the EMPA shall be included as incidental to Section 020200, **Unclassified Excavation**.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Uncontaminated, non-water soluble, non-decomposable, inert, and solid material can be placed in the EMPA. The term includes soil, rock, stone, track bed material, brick, block or concrete for demolition activities that is separate for other waste streams and recognizable as such.
- B. No tires, asphalt, rail ties, trees or root balls that have been cleared may be placed in the EMPA. Future decomposition of wood materials may lead to unexpected settlement of the EMPA and make it unstable.
- C. If material is determined to be unsuitable for the EMPA it must be managed in accordance with local, state and federal regulation. The excess material may not be handled as clean fill regardless of the laboratory test results and must be disposed of at a properly permitted facility. This material may not be sold, traded or given to any

unauthorized third entities. It must be transported and disposed at a CSXT-approved disposal facility.

- D.** The EMPA must be on RAILROAD owned property. The selected location must be in close proximity to the source area of the excess material.
- E.** The EMPA must be constructed in accordance with local, state and federal regulations including final size, height and slope restrictions. These restrictions vary from state to state across the CSXT system. It is the responsibility of the CONTRACTOR to be aware of the requirements for the final EMPA design. Erosion and sediment best management practices (BMPs) must be utilized during construction.
- F.** During transport of the excess material to the selected/approved EMPA, CONTRACTOR is responsible for proper covering of the material and to ensure that no dirt, mud or other unwanted debris is tracked onto public roadways.
- G.** Upon final placement of material the EMPA should be covered with appropriate geotextile and soil cap material. The EMPA shall be permanently seeded and stabilized.

3.2 CONSTRUCTION COMPLETION

- A.** The EMPA shall not be fenced or other barriers put in place unless required by state requirements or directed by the ENGINEER.
- B.** A brief summary report of the EMPA shall be sent to the ENGINEER to be provided to RAILROAD environmental including photographs, a site location map depicting the EMPA in relation to significant features, latitude and longitude coordinates of at least the four (4) corners decimal degrees to six (6) decimals and a site layout map with an aerial background.
- C.** Future use of an EMPA, or material contained within, must be approved by RAILROAD Environmental, Law, and Real Property prior to the disturbance or removal of the material.

END OF SECTION 020215



PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish granular material for use in bedding corrugated metal (CMP) and reinforced concrete pipes (RCP) at the locations as shown on the plans and at such other locations as may be directed. Densely compacted native backfill material shall be used above the bedding material.

1.2 MEASUREMENT AND PAYMENT

- A. The payment for Backfilling (For CMP and RCP) is included in the appropriate drainage item.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Bedding material shall be granular backfill identical to subballast, or a well graded crushed stone or gravel. If crushed stone or gravel is to be used, it shall conform to ASTM designation C-33. Gradation 67. Or approved by geotechnical engineer.

PART 3 - EXECUTION

3.1 EXECUTION

- A. This material shall be placed according to the typical section and compacted in layers not exceeding six (6) inches.
- B. The layers are to be alternately placed to keep the same elevation on both sides of the culvert at all times.
- C. Compaction under the haunches shall be accomplished by utilizing a pole or 2" x 4" timber in the small areas.
- D. Hand tampers shall weigh not less than 20 pounds and have a tamping face not larger than 6" x 6". Mechanical tampers and rollers shall be used in bringing the backfill up to at least 3 feet above the culvert. They shall not strike the culverts while tamping. Smooth rollers will not be allowed in compacting fills around or over culverts.

END OF SECTION 020220

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish and install granular backfill for use in the installation of perforated pipe at the location shown on the plans.

1.2 AUTHORITY

- A. Payment is included in the appropriate drainage item.

PART 2 – PRODUCTS

2.1 MATERIAL

- A. Material shall be granular backfill in conformance with the following standard ASTM gradations:

Sieve Size	Percent Passing
1-1/2 inch	100
1 inch	90 to 100
3/8 inch	25 to 60
Number 4	5 to 40
Number 8	0 to 20

- B. If flowable fill is to be used, refer to Section 070265, **Flowable Fill**.

PART 3 - EXECUTION

3.1 EXECUTION

- A. This material shall be placed according to the typical section and compacted in layers not exceeding six (6) inches or as directed by ENGINEER in writing.
- B. The layers are to be alternately placed to keep the same elevation on both sides of the culvert at all times and densely compacted.
- C. Compaction under the haunches shall be accomplished by utilizing a pole or 2" x 4" timber in the small areas.
- D. Hand tampers shall weigh not less than 20 pounds and have a tamping face not larger than 6" x 6". Mechanical tampers and rollers shall be used in bringing the backfill up to at least 3 feet above the culvert. They shall not strike the culverts while tamping. Smooth rollers will not be allowed in compacting fills around or over culverts.

END OF SECTION 020225

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish and install granular backfill for all perforated pipe as shown on the typical sections or as directed by ENGINEER.

1.2 AUTHORITY

- A. Payment is included in the appropriate drainage item.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Section 020265, **Filter Fabric**
- B. Bedding material shall be granular backfill and conform to the material requirements of Coarse Aggregate Size No. 3 following the standard ASTM gradations:

Sieve Size	Percent Passing
2-1/2 inch	100
2 inch	90 to 100
1-1/2 inch	35 to 70
1 inch	0 to 15
1/2 inch	0 to 5

PART 3 - EXECUTION

3.1 EXECUTION

- A. Backfill shall be placed around the perforated pipe to the dimensions as shown on the plans.

END OF SECTION 020230

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. Offsite borrow material is material obtained off the job site. Off Site Borrow Material shall be used only if the proposed subgrade elevations cannot be obtained using material previously excavated onsite.
- B. No special payment will be made for the construction of temporary haul roads. CONTRACTOR shall include the cost of such haul roads in the bid.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item OFF SITE BORROW MATERIAL shall be the volume in cubic yards of off-site borrow material compacted in place as determined by calculating the difference between total UNCLASSIFIED EXCAVATION placed (onsite material) and the Plan elevation or otherwise directed by the ENGINEER. These quantities will be verified after the CONTRACTOR has taken cross sections following, clearing and grubbing and has calculated earthwork quantities.
- B. Payment for item OFF SITE BORROW MATERIAL shall be made at the unit price bid and be full compensation for supplying all labor, material, transportation, excavation, drainage, permitting, tools, and all else necessary to supply and compact the needed off site borrow material.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The embankment shall be composed of soil or granular material as defined below:
 - 1. Embankment Soil and Compaction - Soil shall include all durable inorganic earth materials having a maximum particle size of three inches (as determined by current ASTM Designation D 422); a plasticity index between 0 and 35 (as determined by current ASTM Designation D 422); and that can be readily placed and compacted to the required density in loose 8-inch layers. Organic soils will not be permitted for use in embankment construction. Fine grained soils which are moisture sensitive may be placed and compacted only during periods of dry weather. Where such soils are used and become wetted, due to natural causes or by fault of CONTRACTOR or by accident, to the extent they exhibit rutting and/or weaving characteristics, when subject to construction traffic, they shall either be removed and replaced with suitable materials or dried as approved by ENGINEER. Any such materials removed may be stockpiled and dried to the required moisture content for later placement and compaction. All soil which is placed on embankment foundation to a plane three feet below the subgrade plane, and to the Plan slope limits shall be compacted to at least 95% of its maximum density and within 2% of its optimum moisture content as determined by current ASTM Designation D 1557, Modified Proctor. All soil placed from subgrade plane and to a plane three feet below the subgrade plane, shall have less than 20% passing a #200 sieve (as determined by current ASTM Designation D 1140) and shall be compacted to at least 100% of its maximum density or to a relative density of 75% of its maximum, whichever is higher, as determined respectively by current ASTM Designation D 1557 or current ASTM Designation D 2049. The in-place density of compacted embankment soils will be determined either by current ASTM Designation D 1556 (Sand Cone Method) or D 2167 (Balloon Method) or D-2922 (Nuclear Method). Any soil layer placed in the embankment and found deficient in required density shall either be brought to specification requirements or removed, as directed by ENGINEER, prior to placing and compacting any subsequent layers.

2. Shale shall include all rock-like materials formed by the natural consolidation of mud, clay, silt and fine sand. Useable shale shall be thinly laminated, comparatively soft and easily split, having a maximum size that can be readily placed and compacted in loose 8-inch layers. Shale which consists predominately of fine particles which can be readily tested for compaction in the laboratory and field shall be placed and compacted in accordance with requirements for soil. Shale containing sufficient amounts of large particles to make checking of the compaction impractical shall not be used within design embankment slope limits. When approved by ENGINEER, such materials may be used to flatten embankment slopes under ten feet in height, if approved by ENGINEER. No embankment flattening shall be done with this material until such time as approval is granted. Shale that is or becomes unstable in the presence of air and water shall not be used for embankment construction.
3. Rock, other than shale, shall include all igneous, metamorphic, and sedimentary rock which cannot be excavated without blasting or by the use of rippers and all boulders and detached stones having a maximum size that cannot be readily placed and compacted in loose 8-inch layers. The use of any micaceous rock or rock containing degradable sulphur minerals or asbestos will not be permitted. Rock shall be placed in uniform loose layers not exceeding in thickness the approximate average size of the larger rock, but limited to a maximum thickness of two feet. Oversize rock shall be reduced in size until it can readily be incorporated into a 2-foot layer. All voids shall be filled by brooming in with spalls and other acceptable filling material and thoroughly wetted and compacted until an unyielding layer is formed. Rock shall not be placed against the backslope of side hill fills nor shall an existing embankment be benched for the placement of a rock embankment or rock slope. The top three feet of an embankment must not be made up of rock fill. The compaction program for rock shall be submitted to ENGINEER for approval. No embankment shall be built until such time as approval is granted.
4. When rock or other embankment material are excavated at approximately the same time, the rock shall be incorporated into the other slopes of the embankment to a 1 on 1 plane extending from the intersection of the design slope and subgrade plane from natural ground to a line three feet below the subgrade plane. The inner portion of the embankment adjacent to the rock fill shall be held at substantially the same elevation as the rock fill, but always above the rock fill at a height sufficient to avoid incorporating water used to wet the rock fill in such quantities as to cause rutting or weaving of the inner embankment fill under the operations of construction equipment.
5. The top three feet of all embankments shall be formed of granular material or soil, as required in Section 020200, **Earthwork**. Provisions should be made to reserve this material from excavation where available. Should such materials be available and not reserved, it shall be furnished and placed by CONTRACTOR at his expense. In the event granular material or soil having less than 20% passing a #200 sieve is not available on-site, this layer shall be paid for at the unit price in the proposal for Off Site Borrow Material.

PART 3 - EXECUTION

3.1 EXECUTION

- A. The tolerance for embankment construction shall be plus or minus 0.1 feet of the dimension indicated on the plans.
- B. Off Site Borrow material shall be obtained as specified herein. The borrow shall be obtained as the specifications indicated below.
 1. Off Site Borrow Excavation shall include excavation, removal and satisfactory disposal of all material from borrow pits, construction of embankments of the excavated material in accordance with the provisions of Section 020200, **Earthwork** and preparing subgrade in accordance with the provision of Section 020200, **Earthwork**.

2. When the total amount of embankment material required exceeds the amount of suitable material to be excavated within the limits of the grading section, sufficient suitable material, approved by ENGINEER, shall be obtained by CONTRACTOR from borrow pits furnished by CONTRACTOR located outside of RAILROAD property, except when permission is given, in writing, by ENGINEER to use a borrow pit which may be available on CSXT property or permission is given by ENGINEER to widen the roadway excavation to obtain additional material.
3. CONTRACTOR shall be required to obtain a release from borrow site owner upon completion. A copy of the release shall be provided to the ENGINEER.
4. All topsoil, sod, brush, weeds, roots and other unsuitable material shall be removed from the surface of borrow pit prior to the removal of any materials. The cost of such removal shall be included in the price bid for Off Site Borrow Material.
5. Trucks, cars or other equipment used for transporting material from borrow pits shall have tight bodies and shall be loaded and covered so that no material will be lost while in transit.
6. The source and quality of borrow material shall be approved by ENGINEER before excavation of such borrow is made.
7. A berm of the original unbroken ground not less than ten feet (10) in width shall be left between slope stakes of the embankment and edge of borrow pits and a similar berm between outside slope of borrow pits and CSXT right-of-way unless otherwise shown on the Plans or approved in writing by ENGINEER.

END OF SECTION 020235

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. Should unsuitable material be encountered such as muck, highly plastic clays or silty unstable material, it shall be removed at the direction of the ENGINEER. In cut sections, plastic material as defined by the American Association of State Transportation Officials Soil Classification as A-2-6, A-2-7, A-4, A-5, A-6 and A-7 shall be removed to a depth of at least 2 feet below subgrade from ditch line to ditch line. Additional depth may be required at the direction of the ENGINEER. Where organic muck, Classification A-8, is encountered in the fill section, it shall be removed within the limits of the toes of slope of the road bed. Where fill exceeds 10 feet in height, width of the section to be mucked shall be three times the height of the fill or as directed by the ENGINEER.
- B. CONTRACTOR shall excavate unstable materials encountered below the line and grade indicated on the plans, which are of such a nature that the use of ordinary dry excavation methods and equipment is impractical.
- C. Unsuitable excavated material shall be disposed following CSX's EMPA guidelines in section 020215, **Excess Material Placement Area (EMPA)** as designated by plans or directed by the ENGINEER. When wasting of unsuitable material is ordered, the material shall, if possible, be deposited in low areas of the property but under no circumstances shall the nearest edge of waste bank be within 10 feet of the berm ditch along a cut section. Waste areas shall be leveled or drained as directed by ENGINEER. CONTRACTOR's proposals will be considered for approval by ENGINEER.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item UNSUITABLE SOILS shall be by the cubic yard of material excavated as determined by mathematical calculations using cross sections developed before and after the work of this item and such work being authorized by the ENGINEER.

Original and final sections for payment shall be taken by the CONTRACTOR and checked by the ENGINEER.

- B. Payment of the item UNSUITABLE SOILS at the unit price bid per cubic yard shall be full compensation for supplying all the labor, materials, equipment, supplies, tools, and all else necessary for removal, draining, storing, transporting and spreading of unsuitable materials.

PART 2 - PRODUCTS

- A. Not used.

PART 3 - EXECUTION

3.1 EXECUTION

- A. The excavation, grading and placement of suitable material establishing the new compacted subgrade shall be to the lines and grades indicated on the drawings, and work shall be done in accordance with the specifications herein and Section 020200, **Earthwork**.
- B. If areas of any unsuitable soils are encountered, they shall be excavated to a firm bedding stratum acceptable to ENGINEER or treated in other manner as described on the plans or as directed by ENGINEER. If any wet excavation is required, it shall be treated similarly. After the excavation, the area shall be backfilled with a suitable material and in a manner as described by ENGINEER, to the lines and grades shown on the plans.

- C. After the excavation of any area, all material that enters the excavated area by sloughage, or from any other cause, shall be removed prior to backfilling. Removal of any such sloughage not caused by the operations will be included in this item.

END OF SECTION 020240



PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work consists of the excavation of material and if required, disposing of excavated material required for trenches, culverts, manholes, etc. All work shall conform to the requirements of Section 020200, **Earthwork**.
- B. Trenches shall be constructed as indicated on the plans and as described under the item for installation of pipe.
- C. Work includes the cost for furnishing, placing and removing, when required or used, all bracing, shoring and cofferdams. Work also includes all water pumping which is incidental to the work.

1.2 MEASUREMENT AND PAYMENT

- A. CONTRACTOR shall determine when supports are required for trench excavation. Guidelines from the Department of Labor (OSHA) must be strictly adhered to.

PART 2 - PRODUCTS

- A. Not used.

PART 3 - EXECUTION

3.1 EXECUTION

- A. The trenches shall be excavated to a tolerance of plus or minus 0.1 feet of the invert elevation shown on the plans.

END OF SECTION 020245

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall provide all materials for and install in place stone as rip-rap as shown on the plans for the protection of slopes of earth embankments, dikes, and channels.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for item RIP-RAP shall be the number of net tons of rip-rap transported and compacted in place as calculated from weigh tickets provided to the CONTRACTOR. CONTRACTOR is responsible to retain weigh tickets and provide OWNER copies with invoice.
- B. Payment for item RIP-RAP shall be the number of net tons in place at the unit price.
- C. Filter fabric shall not be paid for separately but shall be considered incidental to this pay item.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The crushed rock shall be quarried stone of sound quality with 100% passing the twelve (12) inch sieve and 0% passing the six (6) inch sieve.
- B. The stone shall be broken stone produced from sound ledge or large boulders with at least three fractured faces on each piece and free from overburden, spoil, shale or organic material.
- C. The stone shall have a minimum density of 150 pounds per cubic foot. Stones shall not weigh less than 50 pounds and not more than more than 150 pounds and shall be reasonably well graded with no more than 40 percent weighing more than 100 pounds each.
- D. Broken concrete used as rip-rap shall comply to the above specifications and shall be solid, dense, and free from major cracks and flaws.
- E. Filter fabric shall be per Section 020265, **Filter Fabric**.

PART 3 - EXECUTION

3.1 EXECUTION

- A. The surface of the slope, prior to placement of rip-rap, shall be graded and tamped so that the finished surface will conform to the lines and grades specified on the plans.
- B. Material shall be placed by dumping the stone into position over the surface to be protected. A reasonable attempt shall be made to place the larger stones at the bottom of the slope.
- C. The finished surface shall be in close conformity to the lines and grades specified on the plans.

END OF SECTION 020255

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. The work shall consist of furnishing and installing Geogrid, including all labor and equipment for hauling and placing the Geogrid, complete, at locations shown on the plans or as directed by the ENGINEER and maintaining until placement of the stone has been completed and accepted.
- B. The Geogrid shall be placed beneath a minimum of 6 inches of subballast stone at the locations specified. The cost of the ballasting is included under other pay items found in Section 020410, **Railroad Ballasting**.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item GEOGRID shall be the number of square yards of material in place as approved by the ENGINEER. No allowance will be made for the minimum 12 inches of overlap required.
- B. Payment for item GEOGRID shall be full compensation for: furnishing, transporting, placing, and maintaining the GEOGRID.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The GEOGRID shall be as below or equivalent; any equivalent material must be approved by the ENGINEER.

Product Type:	Integrally Formed Biaxial Geogrid
Polymer:	Polypropylene
Load Transfer Mechanism:	Positive Mechanical Interlock
Primary Applications:	Spectra System (Base Reinforcement, Subgrade Improvement)

Product Properties

Index Properties	Units	MD Values ¹	XMD Values ¹
▪ Aperture Dimensions ²	mm (in)	25 (1.0)	33 (1.3)
▪ Minimum Rib Thickness ²	mm (in)	1.27 (0.05)	1.27 (0.05)
▪ Tensile Strength @ 2% Strain ³	kN/m (lb/ft)	6.0 (410)	9.0 (620)
▪ Tensile Strength @ 5% Strain ³	kN/m (lb/ft)	11.8 (810)	19.6 (1,340)
▪ Ultimate Tensile Strength ³	kN/m (lb/ft)	19.2 (1,310)	28.8 (1,970)

Structural Integrity

▪ Junction Efficiency ⁴	%	93
▪ Flexural Stiffness ⁵	mg-cm	750,000
▪ Aperture Stability ⁶	m-N/deg	0.65

Durability

▪ Resistance to Installation Damage ⁷	%SC / %SW / %GP	95 / 93 / 90
▪ Resistance to Long Term Degradation ⁸	%	100
▪ Resistance to UV Degradation ⁹	%	100

Dimensions and Delivery

The biaxial geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 3.0 meters (9.8 feet) or 4.0 meters (13.1 feet) in width and 50.0 meters (164 feet) in length. A typical truckload quantity is 160 to 210 rolls.

Notes

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D4759-02. Brief descriptions of test procedures are given in the following notes.
2. Nominal dimensions.
3. Determined in accordance with ASTM D6637-10 Method A.
4. Load transfer capability determined in accordance with ASTM D7737-11.
5. Resistance to bending force determined in accordance with ASTM D7748-12, using specimens of width two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs, and of length sufficiently long to enable measurement of the overhang dimension.
6. Resistance to in-plane rotational movement measured by applying a 20 kg-cm (2 m-N) moment to the central junction of a 9 inch x 9 inch specimen restrained at its perimeter in accordance with GRI GG9.
7. Resistance to loss of load capacity or structural integrity when subjected to mechanical installation stress in clayey sand (SC), well graded sand (SW), and crushed stone classified as poorly graded gravel (GP). The geogrid shall be sampled in accordance with ASTM D5818 and load capacity shall be determined in accordance with ASTM D6637.
8. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments in accordance with EPA 9090 immersion testing.
9. Resistance to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and aggressive weathering in accordance with ASTM D4355-05.

PART 3 – EXECUTION

3.1 EXECUTION

- A.** The GEOGRID shall be placed at the locations shown on the plans or as directed by the ENGINEER. The surface to receive the GEOGRID shall be prepared to a relatively smooth condition, free of obstructions, depressions, debris, and soft or low density pockets of material. All holes, rips, or flaws made in the GEOGRID shall be repaired by placing a piece of GEOGRID, which is 1.5 feet larger than the hole in the GEOGRID in all directions, directly over the hole before stone is placed on the GEOGRID. The GEOGRID shall be laid smooth and free of tension, stress, folds, wrinkles or creases. The GEOGRID rolls shall be placed to provide a minimum width of 12 inches of overlap for each fabric joint. The use of securing pins will not be permitted. Overlaps will be secured, if necessary, by placing stone windrows on the overlap section. All damage to the GEOGRID during its installation or during placement of the stone shall be replaced or repaired by the CONTRACTOR at no cost to the railroad. Stone shall be placed on the GEOGRID, as specified herein or as shown on the plans, immediately after GEOGRID placement.
- B.** No construction traffic will be permitted directly on the GEOGRID. At least six (6) inches of stone material must be placed before traffic will be allowed in areas where GEOGRID has been placed.

END OF SECTION 020260

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The work shall consist of furnishing filter fabric, all plant, labor and equipment and performing all operations required for hauling and placing the filter fabric, complete, at locations shown on the plans or as directed by the ENGINEER and maintaining until placement of the subballast has been completed and accepted.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item FILTER FABRIC shall be the number of square yards of material in place as approved by the ENGINEER.
- B. Payment for item FILTER FABRIC shall be full compensation for: furnishing, transporting, placing, and maintaining the filter fabric.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. For Placement on Roadbed: The filter fabric shall be nonwoven needle punched, polyester or polypropylene material conforming to the following minimum average requirements:

Property	Minimum average requirement	Test
Weight	10.0 ounces / S.Y.	ASTM D 1910
Apparent opening size	70-120 Std. sieve	ASTM D 4751
Grab tensile strength	240 pounds	ASTM D 4632
Mullen Burst strength	400 p.s.i.	ASTM D 3786
Max Elong. @ failure	40 - 65 %	ASTM D 4632
Permittivity	1.11 / second	ASTM D 4491
Trapezoidal tear	100 pounds	ASTM D 4533
Puncture strength	130 pounds	ASTM D 4833

- B. For Placement under Ballast: The filter fabric shall be nonwoven needle punched, polyester or polypropylene material conforming to the following minimum average requirements in accordance with CSXT's Standard Procedure Bulletin R-16.

Property	Minimum Average Requirements	Test
Weight	16 ounces per Square Yard	ASTM D 1910
Apparent opening size	70 - 120 Standard Sieve	ASTM D 4751
Grab tensile	350 pounds	ASTM D 4632
Mullen burst strength	620 pounds per square inch	ASTM D 3786
Thickness	100 mils	ASTM D 1777
Elongation	40% - 60%	ASTM D 4632
Permittivity	0.201 / second	ASTM D 4491
Trapezoidal tear	150 pounds	ASTM D 4533
Puncture strength	185 pounds	ASTM D 4833

- C. For Placement as Slope Protection: The filter fabric shall be non-woven or woven monofilament polypropylene or

polyester material conforming to the following minimum average requirements:

Item	Minimum average requirement	Test
Apparent opening size	70 Standard sieve	ASTM D 4751
Grab tensile strength	270 pounds	ASTM D 4632
Mullen Burst strength	500 p.s.i.	ASTM D 3786
Permittivity	1.11 / second	ASTM D 4491
Trapezoidal tear	60 pounds	ASTM D 4533
Puncture strength	140 pounds	ASTM D 4833

- D. For Placement with Subgrade Drains: The filter fabric shall be non-woven needle punched polyester or polypropylene material conforming to the following minimum average requirements:

Item	Minimum average requirement	Test
Weight	5.3 ounces per square yard	ASTM D 1910
Apparent opening size	70 Standard sieve	ASTM D 4751
Grab tensile strength	150 pounds	ASTM D 4632
Burst strength	300 p.s.i.	ASTM D 3786
Max. elongation @ failure	40 - 60%	ASTM D 4632
Permeability	0.2 cm / second	ASTM D 4491
Trapezoidal tear	65 pounds	ASTM D 4533
Puncture strength	80 pounds	ASTM D 4833

PART 3 - EXECUTION

3.1 EXECUTION

A. For placement on Roadbed

1. The filter fabric shall be placed at the locations shown on the plans or as directed by the ENGINEER. The surface to receive the fabric shall be prepared to a relatively smooth condition, free of obstructions, depressions, debris, and soft or low density pockets of material. All holes, rips, or flaws made in the fabric shall be repaired by placing a piece of fabric, which is 1.5 feet larger than the hole in the fabric in all directions, directly over the hole before stone is placed on the fabric. The fabric shall be laid smooth and free of tension, stress, folds, wrinkles or creases. The fabric rolls shall be placed to provide a minimum width of 24 inches of overlap for each fabric joint. The use of securing pins will not be permitted. Overlaps will be secured, if necessary, by placing subballast windrows on the overlap section. All damage to the fabric during its installation or during placement of the subballast shall be replaced or repaired by the CONTRACTOR at no cost to the railroad. The fabric shall be protected from sunlight, ultra-violet light, high temperatures, dirt and debris at all times prior to installation. Subballast shall be placed on the fabric, as specified herein or as shown on the plans, immediately after fabric placement.
2. No construction traffic will be permitted directly on the fabric. At least six (6) inches of sub-ballast material must be placed before traffic will be allowed in areas where filter fabric has been placed.
3. The filter fabric shall be placed beneath the subballast on top of the prepared subgrade per the plans or specifications or as directed by the ENGINEER.
4. The CONTRACTOR shall not receive extra compensation for the minimum 24 inches of overlap required.

B. For Placement under Ballast

1. The filter fabric shall be placed at the locations shown on the plans or as directed by ENGINEER. The surface to receive the fabric shall be prepared according to conditions specified under "EARTHWORK." All holes, rips, or flaws in the fabric shall be repaired by placing a piece of fabric, which is 2 feet larger than the hole in the fabric in all directions, directly over the hole before stone is placed on the fabric. The fabric shall be laid smooth and free of tension, stress, folds, wrinkles or creases. The fabric rolls shall be placed to provide a minimum width of 24 inches of overlap for each fabric joint. The use of securing pins will not be permitted. Overlaps will be secured, if necessary, by placing ballast windrows on the overlap section. All damage to the fabric during its installation or during placement of the ballast shall be replaced or repaired by CONTRACTOR at no cost to the railroad. The fabric shall be protected from sunlight, ultra- violet light, high temperatures, dirt and debris at all times prior to installation. Ballast shall be placed on the fabric, as specified herein or as shown on the plans, immediately after fabric placement.
2. No construction traffic will be permitted directly on the fabric. A minimum of eight (8) inches of ballast material must be placed on top of the fabric before any traffic will be permitted in that area. The fabric shall be protected at all times during construction from contamination by surface runoff. All fabric so contaminated shall be removed and replaced with uncontaminated fabric.
3. If it is necessary to overlap rolls or pieces of a geotextile along the longitudinal edge, eighteen (18) inches of overlap shall be used. The CONTRACTOR shall not receive extra compensation for any overlaps. No longitudinal overlaps shall occur between the toes of ballast of any track.
4. At all bridge abutments the geotextile shall be turned down two feet below the finished subgrade against the face of the abutment. As the embankment is replaced against the abutment and the geotextile, the CONTRACTOR shall take special care to ensure that the backfill is adequately compacted to the specified design density. The CONTRACTOR shall also use special care to avoid any damage to the geotextile.
5. The filter fabric shall be placed beneath the subballast on top of the prepared subgrade per the plans or specifications or as directed by the ENGINEER.

C. For Placement as Slope Protection

1. The filter fabric shall be placed at the locations shown on the plans or as directed by ENGINEER. The surface to receive the fabric shall be prepared to a relatively smooth condition, free of obstructions, depressions, debris and soft or low density pockets of material. All holes, rips or flaws made in the fabric shall be repaired by placing a piece of fabric, which is 1.5 feet larger than the hole in the fabric in all directions, directly over the hole before stone is placed on the fabric. The fabric shall be laid smooth and free of tension, stress, folds, wrinkles or creases. The fabric rolls shall be placed to provide a minimum width of 24 inches of overlap for each adjacent strip. When securing pins are necessary in the placement of the fabric, the pins shall be 3/16 inch diameter steel, pointed at one end, and 22 inches long. All damage to the fabric during its installation or during placement of the stone shall be replaced or repaired by CONTRACTOR at no cost to the railroad. The fabric shall be protected from sunlight, ultra-violet light, high temperatures, dirt and debris at all times prior to installation.
2. The fabric shall be laid with the long dimension parallel to the centerline of the channel or shoreline unless otherwise directed by ENGINEER.
3. Securing pins with washers shall be inserted through both strips of the 24" overlapped fabric at not greater than the following intervals along a line through the midpoint of the overlap:

<u>Pin Spacing</u>	<u>Slope</u>
2 feet	Steeper than 3:1
3 feet	3:1 to 4:1
5 feet	Flatter than 4:1

4. Additional pins, regardless of location, shall be installed as necessary to prevent any slippage of the filter fabric.
5. Each securing pin shall be pushed through the fabric until the washer bears against the fabric and secures it

firmly to the foundation.

6. The fabric shall be turned down and buried at all exterior limits.
7. The fabric shall be installed so that the upstream strip of fabric will overlap the downstream strip. If ENGINEER directs that the fabric be placed with the long dimension perpendicular to the centerline of the channel or shoreline, the higher strip of the fabric shall overlap the lower strip.
8. The fabric shall be protected at all times during construction from contamination by surface runoff. All fabric so contaminated shall be removed and replaced with uncontaminated fabric.
9. Work shall be scheduled so that the fabric is exposed no more than 5 days prior to the covering of the fabric with stone.
10. Stone shall not be dropped on the fabric. If CONTRACTOR provides a six (6) inch cushioning layer of sand on top of the fabric, before the dumping of stone, a one (1) foot drop shall be permitted. No separate measurement shall be made for the sand cushion layer. All damage to the fabric during the placement of stone shall be repaired or replaced by CONTRACTOR.

D. For Placement with Subgrade Drains

1. The filter fabric shall be placed at the locations shown on the plans or as directed by the ENGINEER. The surface to receive the fabric shall be prepared to a relatively smooth condition, free of obstructions, depressions, debris and soft or low density pockets of material. All holes, rips, or flaws made in the fabric shall be repaired by placing a piece of fabric, which is 1.5 feet larger than the hole in the fabric in all directions, directly over the hole before stone is placed on the fabric. The fabric shall be laid smooth and free of wrinkles, folds, or creases. The use of securing pins will not be permitted. The fabric shall be secured, if necessary, by placing large stones or bags of soil on the fabric section. All damage to the fabric during its installation or during placement of the backfill shall be replaced or repaired by the CONTRACTOR at no cost to the railroad. The fabric shall be protected from sunlight, ultra-violet light, high temperatures, dirt and debris at all times prior to installation. The filter material shall be placed on the fabric, as specified herein or as shown on the plans, immediately after fabric placement.
2. Initial placement of the fabric shall be at lowest trench grade with the succeeding strips being placed at successively higher grades. Longitudinal overlaps shall be a minimum of 12 inches.
3. Trenches to be lined with fabric shall be graded to obtain smooth side and bottom surfaces so that the fabric will not bridge cavities in the soil or be damaged by projecting rock. The fabric shall be laid flat, but not stretched on the soil, with sides folded back and secured large stones to allow for the placement of stone backfill. The backfill shall be placed and compacted to the depth shown on the plans. The filter fabric sides shall be folded across the top of the backfill with a minimum of 12 inches of overlap.
4. The fabric shall be placed, lining the drain trenches, in accordance with the lines and grades shown on the plans.

END OF SECTION 020265



PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall construct the "Trench Drains" in the locations and to the elevations shown on the plans.
- B. Trench drains will consist of a trench excavated to the depth and width shown on the plans, lined with drainage fabric, and backfilled with suitable material.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item TRENCH DRAINS shall be in linear feet measured from end to end of continuous runs and approved by the ENGINEER.
- B. Payment shall be at the unit price bid per linear foot installed, and shall be full compensation for supplying all labor, equipment, tools, material and all else necessary to perform all trenching, filter fabric, materials, backfilling, and incidentals of installation. Payment shall include the filter fabric necessary to surround the backfill as shown on the typical sections.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Drainage fabric shall meet the requirements stated under Section 020265, **Filter Fabric**.
- B. Backfill material shall be identical to that specified under Section 020230, **Backfill (For Perforated Corrugated C.M.P.)**.

PART 3 - EXECUTION

3.1 EXECUTION

- A. The trench shall be excavated to the limits shown on the plans. Excavation shall follow the specifications set forth under Section 020245, **Trench Excavation**.
- B. Installation of the filter fabric and the backfill material shall conform to that shown on the plans.

END OF SECTION 020300

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish and install asphalt coated, corrugated metal perforated pipe at the locations and to the elevations shown on the plans.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item PERFORATED CMP, shall be in linear feet and be measured from end to end of continuous runs, exclusive of end sections, and passing through the center of included catch basins. Where a run of pipe ends in a catch basin the pipe shall be measured to the centerline of the catch basin.
- B. Payment for perforated corrugated metal pipes will be at the unit price bid per linear foot of pipe in each pipe diameter installed and shall be full compensation for supplying all labor, materials, equipment, tools, supplies and all else necessary to perform all trenching, backfilling, fittings, necessary hardware and incidental expenses of installation. Payment shall include the filter fabric necessary to surround the backfill as shown on the typical section. All tees and elbows shall be included in the price bid for this item.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Pipe shall have 2-2/3 inch x 1/2 inch corrugations with a nominal diameter equal to that specified on the plans.
- B. Asphalt coating shall conform to the requirements of the AREMA recommendations for Bituminous Coated Corrugated Metal Pipe and Arches.
- C. C.M.P. perforations shall conform to the requirements of AASHTO M-36 specifications for location and diameter of perforation holes.
- D. Tees and elbows shall be a size and gage corresponding to the pipe to which they connect and shall come complete with connections.
- E. Joining pipe CONTRACTOR use minimum 24" bands.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Pipes shall be installed as per the AREMA recommendations for installation of pipe, Chapter 1, Part 4, current year edition, with special granular backfill. Special granular backfill shall conform to the requirements as described under Section 020245, **Trench Excavation** and Section 020225, **Backfilling (For Perforated C.M.P.)**.
- B. Should it be necessary to install pipe other than in a trench, pipe shall be laid with sufficient cover as directed by the ENGINEER, with thoroughly tamped backfill around the pipe to protect the pipe from any movement or distortion.
- C. Perforated pipes generally have 3 or 4 lines of perforations. The perforations should be installed with 2 of the lines in the bottom half of the pipe. A line of perforations shall not be installed at the invert of the pipe.

END OF SECTION 020305

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish material for and install corrugated metal pipe (CMP) at the locations and to the elevations shown on the plans. Pipe covered under this Section shall not be used for conveyance of sanitary or industrial wastes.
- B. The installation of galvanized corrugated steel pipe, de-watering, etc., required for the completion of the project in accordance with the drawings, as specified herein, and/or as directed by the Engineer. This Section shall be in general accordance of AREMA chapter 1, part 4, section 4.3.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item FURNISH, CORRUGATED METAL PIPE CULVERT and CORRUGATED METAL PIPE CULVERT (RAILROAD FURNISHED) shall be in the units of linear feet measured from end to end of continuous runs, exclusive of end sections, and passing through the center of included catch basins. Where a run of pipe ends in a catch basin, the pipe shall be measured to the midpoint of the catch basin.
- B. Payment for item FURNISH, CORRUGATED METAL PIPE CULVERT will be at the unit price bid per linear foot of pipe in each pipe diameter installed and shall be full compensation for all labor, material, equipment, tools, supplies, and all else necessary to perform all trenching, backfilling, necessary hardware and incidental expenses of installation. Payment shall include fabrication, delivery and full installation of metal end sections or metal end walls/head walls, unless these items are specifically bid separately from the pipe. All tees and elbows shall be included in the price bid.

Payment for item CORRUGATED METAL PIPE CULVERT (RAILROAD FURNISHED) will be at the unit price bid per linear foot of pipe in each pipe diameter installed and shall be full compensation for all labor, material, equipment, tools, supplies, and all else necessary to perform all trenching, backfilling, necessary hardware and incidental expenses of installation. Payment shall include fabrication, delivery and full installation of metal end sections or metal end walls/head walls, unless these items are specifically bid separately from the pipe. All tees and elbows shall be included in the price bid.

1.2 GENERAL

- A. Hydraulic Design – Shall be based on the 100-year/24-hour storm event leaving minimum 2 feet of freeboard between the water surface elevation and bottom of rail, or a headwater surface no more than 1.5 times opening height of culvert, unless otherwise approved by the ENGINEER. Calculating the capacity of an existing or proposed drainage structure should be completed per AREMA recommendation.
- B. Minimum pipe size is 36-inch diameter for any storm water conveyances crossing under track including all connecting portions outside of the track area. Minimum size is 24-inch diameter for storm water conveyances that do not have any segments crossing under the track.
- C. Adjacent pipes of dissimilar sizes and shapes shall have the same invert elevation.
- D. Multiple pipes shall be spaced at no more than 2 pipe diameters apart, center to center.
- E. Pipes shall be installed with headwalls, parapets, wingwalls, and apron if required for hydraulics, scour prevention, or right-of-way reasons.
- F. Pipe material selection shall be based on anticipated abrasion levels and environmental conditions as follows:

1. Abrasion due to bed load of sand/gravel/rock shall be considered “low” for 5 ft./sec velocity or less, “moderate” for 5 to 15 ft./sec. and “severe” for 15 ft./sec. and more. The ENGINEER must approve use of CMP for severe conditions.
2. pH range between 5.0-8.0 and soil resistivity greater than 2,000 ohm-cm considered average conditions. Conditions outside these ranges warrant specialized coating.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Corrugated steel shall be zinc coated (galvanized) in accordance with ASTM A760 Type 1 and AASHTO Designation M 218. Corrugated steel pipe shall be manufactured in accordance with AASHTO M 36 and shall be annular riveted with a profile of 2-2/3 x 1/2 inches or helically corrugated welded seam, unless otherwise specified. If helically corrugated welded seam pipe is used, re-rolled ends (four corrugation) will be required to mate with 24-inch-wide annular corrugated bands.
- B. All CMP shall have coating consisting of bituminous asphalt, aluminized type 2, or polymer applied fully to inside and outside of pipe and all coupling bands.
- C. Pipe coupling bands shall be one or two-piece annular corrugated, and formed from galvanized steel sheet conforming to ASTM A 525 and AASHTO Designation M 218. Coupling bands shall be minimum 24-inched long. Dimple band couplers shall not be used.
- D. Coupling bands shall be fastened using a minimum of three ½ inch diameter galvanized bolts. Pipes 48-inches and larger shall use a minimum of four ½ inch diameter rods and silo type lugs.
- E. Bituminous coating shall be shop applied fully inside and outside of the pipe and shall conform to the requirements of AASHTO M 190 Type A. Any damage to the bituminous coating shall be repaired by patching before the surface is backfilled or grouted.
- F. Bituminous paved inverts, where specified on the plan or specifications, shall conform to AASHTO Designation M 190-Type C. They shall cover 25% of the bottom of culvert periphery for circular pipes and 40% of the bottom culvert periphery for pipe arches. Bituminous paved inverts shall be shop applied.
- G. Aluminized Type 2 CMP shall be formed from aluminized sheets conforming to ASTM A 819 and AASHTO M 274.
- H. Polymer protective coating shall conform to AASHTO M 246 grade 250/250.
- I. Gage of pipe to be used for storm water system connects (not under live load) is as follows:

Diameter	Gage	Cover Limits	Min. Size Band
12"	16	2' – 50'	7"
15"	16	2' – 40'	7"
18"	14	2' – 50'	12"
21"	14	2' – 45'	12"
24"	14	2' – 40'	12"
30"	12	2' – 55'	12"
84"	8	2' – 40'	24"

J. Gage of pipe to be used as perpendicular crossings as culverts is as follows:

Diameter	Gage	Cover Limits	Min. Size Band
36"	12	2' – 40'	24"
42"	12	2' – 50'	24"
48"	12	2' – 45'	24"
54"	10	2' – 50'	24"
60"	10	2' – 45'	24"
66"	10	2' – 45'	24"
72"	8	2' – 50'	24"
78"	8	2' – 45'	24"
84"	8	2' – 40'	24"

Span & Rise	Gage	Cover Limits
36" x 22"	12	2' – 45'
43" x 27"	12	2' – 40'
50" x 31"	10	2' – 60'
58" x 36"	10	2' – 55'
65" x 40"	10	2' – 50'
72" x 44"	8	2' – 60'
79" x 49"	8	2' – 55'
85" x 54"	8	2' – 50'

H. Tees and elbows shall be a size and gage corresponding to the pipe to which they connect and shall come complete with connections.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Pipe shall be installed as per AREMA recommendation "**Installation of Pipe**". The pipe shall be placed on class B bedding, which entails placing compacted granular backfill around the pipe to the limits shown on the typical sections. The granular backfill shall conform to the requirements as described under Section 020220, **Backfilling (For Use with C.M.P.)**.
- B. Should it be necessary to install pipe other than in a trench, pipe shall be laid with sufficient cover as directed by ENGINEER, with thoroughly tamped backfill around the pipe to protect the pipe from any movement or distortion.
- C. Where existing pipes are to be extended, connection collars shall be furnished and installed by the CONTRACTOR. Connection collars shall be either manufactured collars specifically for connecting the existing pipe type to the extension or a cast in place concrete collar as shown in the typical sections. Connection collars shall be approved by the ENGINEER.

END OF SECTION 020310

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. The reinforced concrete catch basin, with frame and grate, shall be furnished and installed in the locations shown on the plans.
- B. The catch basin shall conform to the type specified on the plans.
- C. Work includes all trenching, backfilling, incidental work, and hardware.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for the item REINFORCED CONCRETE CATCH BASINS shall be made in the units per each catch basin complete with rim and grate furnished and installed of each type shown in the plans.
- B. Payment at the price bid for each catch basin shall be full compensation for all labor, material, equipment, tools, supplies and all else necessary to furnish, install, excavate, install, backfill and all other items of expense for each catch basin.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Asphalt sealant shall conform to the AREMA recommendation for Bituminous Coated Corrugated Metal Pipe and Arches.
- B. The frame and the grate shall be of a type and size to fit the top of the catch basin, and shall be a type equal to that specified on the plans. Where Neenah type R-3475, R-3807, and R-1878-A9L grates are specified on the plans, all specified grates or approved equals shall meet the following requirements:
 - 1. The frame and the grate shall be gray iron, ASTM A48 class 35-B.
 - 2. Grate or lid shall be ductile iron, ASTM A536 grade 65-45-12.
- C. Concrete shall comply with the requirements of governing State's Department of Transportation for the location of the project.
- D. Ladder rungs shall be made from one inch diameter, galvanized wrought iron. Rungs shall be twelve (12) inches long.
- E. Catch basin material shall conform to the material requirements of the governing State's Department of Transportation for the location of the project.

PART 3 - EXECUTION

3.1 EXECUTION

- A.** Installation of catch basins shall conform to the requirements of the governing State's DOT specifications and the construction requirements of the governing State's DOT standard construction drawings as noted on the plans.
- B.** Details for construction and installation of catch basins are noted on the plans.
- C.** All excavation and backfill shall conform to the requirements for Section 020245, **Trench Excavation** and Section 020220, **Backfilling (for use with C.M.P. and R.C.P.)**.

END OF SECTION 020315



PART 1 - GENERAL

1.1 DESCRIPTION

- A. Corrugated metal catch basins, asphalt coated, with frame and grate shall be furnished and installed at the locations shown on the plans.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement of the item CORRUGATED METAL CATCH BASIN shall be in the units of each measured for each catch basin installed complete.
- B. Payment for corrugated metal catch basins made at the price bid shall be full compensation for all labor, materials, equipment, tools, supplies and all else necessary for each catch basin complete with rim and grate installed for each type shown on the plans, including excavation, material, backfill, incidental expenses and hardware.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Pipe shall have 2-2/3 inch x 1/2 inch corrugations with a nominal diameter equal to that specified on the plans. The gage of the catch basin shall be equal to the largest gauge of the pipes which it connects. Catch basins shall be asphalt coated.
- B. Asphalt coating shall conform to the AREMA recommendation for Bituminous Coated Corrugated Metal Pipe and Arches.
- C. The frames and grates shall be a type and size to fit the upper end of the catch basin and shall be a type equal to that manufactured by the Neenah Foundry Co., type R-5900-A or B, as shown on the plans. All specified frames and grates or approved equals shall meet the following requirements:
 - 1. The frames and grates shall be grey iron, ASTM A48 class 35-B.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Details for specific types of catch basins can be found on the plans.
- B. After the excavation and placement of the catch basin has been completed, the catch basin shall be backfilled with suitable backfill material from the bedding to the top of the catch basin a distance of one (1) foot surrounding the outside of the pipe.
- C. All excavation and backfill shall conform to the requirements for Section 020245, **Trench Excavation** and Section 020220, **Backfilling (For use with C.M.P. and R.C.P.)**.

END OF SECTION 020320

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish material for and install in place reinforced concrete pipe in the locations and to the elevations shown on the plans.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for item REINFORCED CONCRETE PIPE shall be in linear feet installed from end to end of continuous runs, exclusive of end sections, and passing through the center of included catch basins. Where a run of pipe ends in a catch basin, the pipe shall be measured to the center line of the catch basin.
- B. Payment for REINFORCED CONCRETE PIPE will be at the unit price bid per linear foot of pipe in each pipe diameter installed in place shall be full compensation for all labor, material, equipment, tools, supplies and all else necessary to perform all trenching, backfilling, necessary hardware and incidental expenses of installation. All tees and elbows shall be included in the price bid for this item.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Reinforced concrete pipe shall be bell and spigot pipe with "O" ring gasket, or tongue and groove with RAM-NEK type flexible gasket meeting the current ASTM designation: C-76, class V, wall C, unless designated otherwise on the plans.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Pipe shall be placed in accordance with AREMA recommendations Installation of Pipe Chapter 1, Part 4, latest version. The pipe shall be placed in class B bedding that entails placing compacted granular backfill material around the pipe as shown on the typical sections and in accordance with Section 020220, **Backfilling (for use with C.M.P. and R.C.P.)**.
- B. Where existing pipes are to be extended, connections shall be made to create a watertight connection. Concrete collars may be required to connect the existing pipe to the extension. Connection collar details are shown in the typical plan sections. Connection collars are to be approved by the ENGINEER.

END OF SECTION 020325

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PART 1 – GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish material for and install in place reinforced concrete box culvert (RCBC) in the locations and to the elevations shown on the plans. RCBC may be cast-in-place or made of precast sections, as shown on the plans.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for item REINFORCED CONCRETE BOX CULVERT shall be by the number of linear feet installed from end to end of continuous runs, exclusive of end sections, and passing through the center of included catch basins. Where a run of REINFORCED CONCRETE BOX CULVERT ends in a catch basin, the culvert shall be measured to the centerline of the catch basin.
- B. Measurement and payment for items such as wingwalls, headwalls, aprons, parapet and sealant if required shall be considered incidental for item REINFORCED CONCRETE BOX CULVERT.
- C. Payment for REINFORCED CONCRETE BOX CULVERT will be at the unit price bid per linear foot of culvert in each size installed in place. Said unit price shall be full compensation for furnishing all labor, materials, equipment, tools, forms, supplies, and all else necessary accessories, supervision, engineering and all other items of expense to perform all trenching, backfilling, necessary hardware and incidental expenses of installation.

1.3 GENERAL

- A. Hydraulic design shall be based on the 100-year/24-hour storm event leaving minimum 2 feet of freeboard between the water surface elevation and bottom of rail, or a headwater surface no more than 1.5 times opening height of culvert, unless otherwise approved by the ENGINEER. Calculating the capacity of an existing or proposed drainage structure should be completed per AREMA recommendation.
- B. The RCBC shall be designed for Cooper E80 loading, plus impact, per AREMA recommendation.
- C. Minimum box culvert size for new installations within CSXT ROW shall be 48-inches by 48-inches unless otherwise approved by the ENGINEER.
- D. Adjacent pipes of dissimilar sizes and shapes shall have the same invert elevation.
- E. Multiple precast boxes shall be spaced as close together as practical, leaving a minimum of 4-inches for flowable fill backfill or 24-inches for compacted crushed stone backfill between outside edge to edge of adjacent boxes.
- F. Boxes shall be installed with headwalls, parapets, wingwalls, and apron if required for hydraulics, scour protection, or right-of-way reasons. Headwalls and parapet shall be cast monolithic or doveled into boxes.
- G. Box joints shall be tongue and groove style with minimum of two fully recessed mechanical couplers per joint, or embedded post-tensioning rods.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. All materials required for the system shall conform to the requirements set forth in the contract documents.
- B. Unless contract documents state otherwise, Precast concrete structures shall conform to the applicable material and testing requirements of Section 070260, **Cast-in-Place Concrete**, including reinforcing steel. Concrete shall have a minimum 28-day compressive strength of 5,000 psi. The air entrainment in the concrete shall be between 5 and 7 percent.

- C. Precast concrete box culvert sections shall be indelibly marked with the following information on the interior of each precast unit by indentation, water proof paint, or other approved method: Year of manufacture, milepost, name or trademark of manufacturer, and design minimum earth cover. As example:

2018
MP XXX 123
XYC COMPANY
MIN 5 FT COVER

- D. Precast concrete box culvert sections shall be handled in a manner that prevents chipping, cracks, fractures, and excessive bending stress. Precast culvert sections shall not be shipped before the concrete attains the required 28-day strength.
- E. Crushed Stone Backfill – Shall be granular backfill material identical to subballast, or a well-graded crushed stone or gravel conforming to ASTM C-33, Gradation 67, or as approved by the ENGINEER.
- F. Sealant (for waterproof structures) – If required by ENGINEER, shall be bulk mastic liquid butyl, or butyl sealant tape (CS-102 or equal), minimum 1-inch thick.
- G. Fabric – If required by ENGINEER, shall be nonwoven geotextile per Section 020265, **Filter Fabric**.
- H. Flowable Fill Backfill – Shall be as specified in Contract Documents. Minimum strength shall be 100psi at 28 days and per Section 070265, **Flowable Fill**.
- I. Mechanical Couplers – shall be hot-dipped galvanized (ASTM A153) or stainless steel (AISI Type 316 or 304) with minimum 1-inch diameter.

PART 3 – EXECUTION

3.1 GENERAL

- A. The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Minimum project submittals are:
1. Shop Drawings sealed by a registered engineer from the state in which the work is being performed;
 - a. One (1) complete electronic copy of detailed shop drawings shall be submitted to the ENGINEER for approval prior to starting fabrication of any precast concrete box culvert sections. Shop drawings shall include calculations, show reinforcement details, all dimensions, and couplers as required. By approving and submitting shop drawings, the CONTRACTOR thereby represents that they have determined and verified all field measurements, field construction criteria, materials, catalog numbers and similar data, or will do so, and that they have checked and coordinated the shop drawings with the requirements of the work and of the contract documents. After approval of shop drawings, the CONTRACTOR shall supply the CSXT with one (1) set of reproducible approved drawings.
 2. CONTRACTOR shall submit to the ENGINEER detailed work plan including plan to prepare, verify, and document foundations/subgrade prior to mobilization.
 3. CONTRACTOR shall submit to the ENGINEER dewatering plan, if required by project site conditions.

3.2 DELIVERY AND STORAGE OF MATERIAL

- A. Materials shall be handled and stored according to manufacturer's recommendations. Design shall account for any stresses induced through the shipping and handling of the product.
- B. CONTRACTOR shall handle and store materials only in approved areas.

3.3 SITE PREPARATION

- A. Prepare culvert subgrade to a minimum bearing capacity of 2,500 pounds per square foot extending a minimum of 5-feet beyond the limits of each box, or as directed by the ENGINEER.

- B.** Provide dewatering as necessary to maintain a dry and firm subgrade until culvert boxes have been installed and backfilled.

3.4 INSTALLATION

- A.** Sections: Precast concrete box culvert sections shall be laid with the groove end of each section up-grade, and the sections shall be tightly joined. Recessed mechanical couplers or embedded post-tensioning rods to be used only to hold box sections together, not for pulling sections tight. Joint openings between sections should be as tight as practicable and limited to a maximum of $\frac{3}{4}$ inch openings. Joints shall be sealed if required by the ENGINEER;
- B.** For waterproof structures, butyl tape or bulk mastic shall be installed in accordance with the recommendations. All joints shall be trimmed clean on the inside after sealing; Please sealant as follows:
1. Liquid butyl on outside top and 12-inches down the outside sides and on inside bottom and sides; or
 2. Butyl tape along inside bottom and halfway up sides of bell end and along outside top and halfway down sides of spigot end. Locate tape approximately $\frac{1}{2}$ inch from shoulder
- C.** For non-waterproof structures, place a 2-foot-wide piece of filter fabric around the exterior top and sides of each precast joint. The fabric shall be centered with 1 foot on each side of the joint. The fabric shall be attached to the wall and top of each section to prevent the fabric from slipping off the joint during backfilling operations. Place liquid butyl or non-shrink grout along interior bottom to 2-feet above bottom haunch.
- D.** Backfill between boxes with compacted maximum 12-inch lifts of crushed stone material or with flowable fill. Stone backfill shall extend a minimum 12-inches above top of box whether or not flowable fill is used.
- E.** For excavation, fill placement and compaction requirements other than herein this section, refer to requirements of Section 020245, **Trench Excavation**, and Section 020220, **Backfilling (For use with CMP and RCP)**.

3.5 INSPECTION

- A.** Culverts and sealants shall be inspected and approved by the ENGINEER before any backfill is placed.
- B.** Any culvert found to be vertically or horizontally out of alignment, deformed, or structurally damaged shall be taken up and re-laid at no expense to the CSXT.

END OF SECTION 020330

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PART 1 – GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish material necessary to install solid wall steel pipe culvert by the JACK-AND-BORE method in the locations and to the elevations shown on the plans. The solid wall steel pipe may be supplied by the CSXT, or may be furnished by the CONTRACTOR, as specified in the Contract Documents.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for items FURNISH, JACK AND BORE STEEL PIPE CULVERT and JACK AND BORE STEEL PIPE CULVERT (RAILROAD FURNISHED) shall be by the number of linear feet of pipe installed from end to end, exclusive of end walls or end sections.
- B. Payment for item FURNISH, JACK AND BORE STEEL PIPE CULVERT will be at the unit price bid per linear foot of pipe in each size installed in place. Said unit price shall be full compensation for furnishing all labor, materials, tools, equipment (set-up and dismantle), forms, supplies, accessories, supervision, excavation, shoring, dewatering, pressure grouting handling and splicing of pipe, engineering and all other items of expense incidental to installation.

Payment for item JACK AND BORE STEEL PIPE CULVERT (RAILROAD FURNISHED) will be at the unit price bid per linear foot of pipe in each size installed in place. Said unit price shall be full compensation for furnishing all labor, tools, equipment (set-up and dismantle), forms, supplies, accessories, supervision, excavation, shoring, dewatering, pressure grouting handling and splicing of pipe, engineering and all other items of expense incidental to installation.

1.3 GENERAL

- A. Hydraulic Design – Shall be based on the 100-year/24-hour storm event leaving minimum 2 feet of freeboard between the water surface elevation and bottom of rail, or a headwater surface no more than 1.5 times opening height of culvert, unless otherwise approved by the ENGINEER. Calculating the capacity of an existing or proposed drainage structure should be completed per AREMA recommendation.
- B. Minimum pipe size is 36-inch diameter.
- C. Adjacent pipes of dissimilar sizes and shapes shall have the same invert elevation.
- D. Multiple pipes shall be spaced at no more than 2 pipe diameters apart, center to center.
- E. Pipes shall be installed with headwalls, parapets, wingwalls, and apron if required for hydraulics, scour prevention, or right-of-way reasons.
- F. For pipe abandonment refer to Section 070190, **Grout Existing Structure**.

PART 2 - PRODUCTS

2.1 STEEL PIPE

- A. The pipe shall be ASTM A139, Grade B with minimum yield strength of 35,000psi.
- B. Minimum wall thickness shall be in accordance with AREMA Table 1-5-5, or as specified by the Engineer.
- C. Joints in pipe sections shall be field welded with full penetration single 'V' groove butt weld, all around. Welding shall be per AWS D1.1.
- D. Metal end sections consisting of pipe reducers or end walls/head walls, if required, shall consist of ASTM A36 steel plate with minimum wall thickness of ½ inch. End sections shall be welded all around with minimum ¼ inch fillet to the host pipe with per AWS D1.1.

2.2 NON-SHRINK STRUCTURAL GROUT (FOR GROUTING PIPE ANNULUS)

- A. Shall be mixture of cement, sand, water, and admixtures.
- B. Shall be highly flowable.
- C. Shall have minimum 28-day unconfined compressive strength of 2,000 psi, unless otherwise indicated on the plans.

PART 3 - EXECUTION

3.1 GENERAL

- A. The CONTRACTOR shall prepare and deliver the following technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work.
 - 1. Installation details and arrangement to be used;
 - 2. Shoring plans and calculations sealed by licensed professional engineer, if required;
 - 3. Steel certifications unless steel is supplied by CSXT;
 - 4. Non-shrink structural grout mix design.

3.2 DELIVERY AND STORAGE OF MATERIAL

- A. Materials shall be handled and stored according to manufacturer's recommendations.
- B. CONTRACTOR shall handle and store materials only in approved areas.

3.3 INSTALLATION

- A. The jack-and-bore CONTRACTOR shall be prepared to perform the installation on a 24-hour, continuous basis if directed by the ENGINEER. If the boring is halted within a distance of 25 feet of centerline of track, the heading of the bore shall be shored immediately.
- B. The jack-and-bore shall be in accordance with the current AREMA recommendations, Earth Boring and Jacking Culvert Pipe Through Fills." (Chapter 1, Manual of Railway Engineering). This operation shall be conducted without hand mining ahead of the pipe and without the use of any type of boring, auguring, or drilling.
- C. Jack and bore installations shall have a bore hole not exceeding the outside diameter of the pipe by more than ½ inch.
- D. Boring and/or receiving pits shall be properly shored and dewatered. Shoring shall be designed for live load from construction equipment and/or rail as required. OSHA regulations apply to all worksite excavations.
- E. The use of water or other liquids to facilitate casing emplacement and spoil removal is prohibited.
- F. If, during installation, an obstruction is encountered which prevents installation of the pipe, notify the ENGINEER immediately and, if directed by the ENGINEER, abandon the pipe in-place and immediately fill with grout or non-excavatable flowable fill (refer to Section 070265 **Flowable Fill**). A new installation procedure and revised plans must be approved by the ENGINEER before work can resume.
- G. The track shall be continuously monitored during boring within the live load influence zone. If track movement occurs, work must stop, the heading shall be bulk headed, and the ENGINEER shall be notified immediately. The Contractor must propose an alternate procedure for ENGINEER approval before proceeding.
- H. Bracing and backstops shall be designed for continuous, non-stop usage.
- I. The front of the pipe shall be provided with mechanical arrangements or devices that will prevent the auger from leading the pipe.
- J. The auger and cutting head arrangement shall be removable from within the pipe in the event an obstruction is encountered.
- K. The auger head shall not advance more than 18-inches ahead of the casing pipe.
- L. The face of the cutting head shall be arranged to provide a reasonable obstruction to the free flow of soft or poor material.

- M.** If voids develop around the pipe, the CONTRACTOR shall pressure grout (using non-shrink structural grout) all voids surrounding the pipe through grout port holes installed in top and sides of pipe. A minimum of 4 holes per grout location (transverse to pipe alignment) with longitudinal spacing of 10-feet center to center of grout location shall be required, unless otherwise approved by ENGINEER.
- N.** Any method that employs simultaneous boring and jacking that does not have the above approved arrangement will not be permitted.
- O.** CONTRACTOR shall remove and dispose of all material and supplies in accordance with local, State, Federal, and CSXT policy leaving work site clear of any and all debris.

END OF SECTION 020340

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall construct the chain link fence and chain link gates in the location as shown on the plans.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for the item CHAIN LINK FENCE shall be per linear foot of fence installed as measured through the top chord passing through the centerline of each post.
- B. Measurement for the item CHAIN LINK FENCE GATES shall be per each gate installed for each size specified. Price shall include all costs for hardware, gate posts, and bracing in adjacent panels of fence.
- C. Payment for the items CHAIN LINK FENCE and CHAIN LINK FENCE GATES at the unit prices bid shall be full compensation for all labor, material, equipment, tools, supplies and all else necessary to provide the fencing and gates complete and in place.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. All materials used for the fence and gate construction shall conform to AASHTO M 181.
- B. Material for the fencing shall be AASHTO M 181 type I, II, III or IV.
- C. Grade 2 steel posts, rails, and gate frames shall be used unless otherwise noted on the plans. The top rails and compression braces shall consist of grade 2 steel.
- D. The fabric shall be AASHTO Type I, class D, 9 gauge, or approved equal.
- E. **The minimum pipe sizes for fence components shall be as follows:**

Component	Fence industry O.D. (grade 2)	Nominal pipe Size I.D.
Line posts	2-1/2 inch	2 inch
Gate posts	4 inch	3-1/2 inch
Corner posts	3 inch	2-1/2 inch
Top rails	1-5/8 inch	1-1/4 inch
Compression braces	1-5/8 inch	1-1/4 inch

- F. All posts shall be crowned with an approved top so designed as to fit securely to the top of the post and carry the top rail.
- G. Concrete for post foundations shall have minimum 28 day strength of 2800 psi.
- H. Tension rods shall be 3/8 inch round rods with drop forged turnbuckles or other similar type of adjustment.
- I. Fence fabric shall be woven into an approximately 2 inch diamond mesh. Top and bottom selvages are to have twist.
- J. Coupling or expansion sleeves shall be outside sleeve type and be at least six (6) inches long.
- K. Fabric bands shall be not less than 1/8 inch x 3/4 inch in sections. Stretch bars shall be not less than 1/4 inch x 3/4 inch in section. Tie wire shall be 9 gage.

- L. Barbed wire shall consist of 12-1/2 gage wire with 14 gage 4 point barbs spaced approximately five (5) inches apart. All wire shall be zinc-coated with a minimum coating of 0.80 ounces per square foot of surface area on 12-1/2 gage wire and 0.65 ounces per square foot of surface area on 14 gage wire.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Barbed wire extension arms shall be at an angle of approximately 45 degrees, and shall be fitted with clips or other means for attaching three lines of barbed wire and/or razor ribbon coil(s) as specified on the plans and in accordance with the manufacturer's recommendations. Extension arms shall be tilted away from the railroad facility. If barbed wire is to be used, the top outside wire shall be placed approximately twelve inches horizontally from the fence line and the other wires spaced uniformly between the top of the fence fabric and the outside barbed wire.
- B. The posts shall be set in concrete bases as shown on the drawings. The posts shall be plumb and true to the line of the fence. "Pull posts," defined as line posts braced to adjacent line posts, shall be spaced at intervals not exceeding 500 feet. End, gate, and end corner pull posts shall be braced to the adjacent line post, and corner and pull posts to the two adjacent line posts in the manner shown on the plans. Changes in line of 30 degrees or more shall be considered as corners.
- C. The top rails shall pass through the ornamental tops of the line posts thereby forming a continuous brace from end to end of each stretch of fence. The lengths of the top rail shall be joined by sleeve type couplings. The top rails shall be securely fastened to the terminal posts by pressed steel fittings.
- D. The chain link fabric shall be placed approximately two inches above the ground and on a straight grade between posts. Chain link fabric shall be placed on the face of the post away from any paved areas.
- E. The fabric shall be stretched taut and securely fastened to the posts. Stretching by motor vehicle will not be permitted. Fastening to the end, gate, corner, and pull posts shall be with stretcher bars and fabric bands spaced at one-foot intervals. The fabric shall be cut and each span shall be attached independently at all pull and corner posts. Wire, metal bands or other approved material shall be used for fastening the fabric to the posts and to the top rails.
- F. Rolls of wire fabric shall be joined by weaving a strand into the ends of the rolls to form a continuous mesh.

END OF SECTION 020400



PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work in this section includes furnishing all labor, equipment, materials, tools, and supplies for the installation of highway grade crossings complete including: flange way materials; detours; signage; barricades; dress grading and clean up.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for the item BARRICADES & DETOURS shall be per each road closing. Measurement will be made once per crossing regardless of the number of times the crossing is closed and re-opened to highway traffic.
- B. Payment for the item BARRICADES & DETOURS at the per each price bid shall be full compensation for supplying all labor, materials, tools, equipment, supplies, all other items of expense to close and re-open the crossing.
- C. Measurement for the item ASPHALT PAVING shall be per ton of asphalt installed. CONTRACTOR shall supply truck weight tickets from the asphalt supplier.
- D. Payment for the item ASPHALT PAVING at the unit price bid shall be full compensation for supplying all labor, materials, equipment, tools and all other items of expense to saw cut existing roadway, remove and dispose of all road materials, prepare sub-grade, install asphalt, final dress grade and clean up road crossing.
- E. Measurement of the item CROSSING SURFACE (CONCRETE) and CROSSING SURFACE (TIMBER) shall be by the track foot measured from end to end of the crossing surface installed.
- F. Payment for the items CROSSING SURFACE at the unit price bid shall be full compensation for all labor, equipment, tools, and all other items of expense to install crossing surface.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All crossing materials with the exception of the asphalt products; road sub-base; and tack coat for the crossings will be supplied by the RAILROAD. CONTRACTOR shall supply asphalt products and road sub-base.
- B. The highway grade crossing shall consist of 6 inches of sub-base, a tack coat, 4-1/2 inches of base course and 1-1/2 inch of wearing surface or as shown on the plans.
- C. The sub-base shall be stone, gravel or slag meeting the requirements of the governing State's DOT specifications. The fine grading and surface compaction of the sub-base is a part of this item.
- D. The sub-base shall be prepared and a tack coat shall be applied uniformly in conformance with the governing State's DOT specification.
- E. The asphalt base shall consist of asphalt binder conforming to the governing State's DOT specifications. The asphalt wearing surface shall be in accordance with the governing State's DOT specifications and approved by the ENGINEER.

PART 3 - EXECUTION

3.1 EXECUTION

- A.** CONTRACTOR will be responsible for the unloading, inventorying, storing, and protecting the crossing material.
- B.** The CONTRACTOR shall coordinate with the proper governmental agency or outside party responsible for the crossing. The street and road closures must be coordinated prior to closing. Proper barricades must be placed at all crossings during the time that they are closed to prohibit vehicles from entering the work zone. All state and local regulations must be met in the erection and installation of these barricades.
- C.** Where ballast has been placed in trackwork, the ballast shall be considered suitable sub-base material within the limits on the typical sections.
- D.** Any road crossing over the Railroad's track at grade shall be installed in accordance with CSXT Standard Drawings, latest revisions.
- E.** No splices (rail joints) will be permitted within the confines of the crossing, including road shoulders.
- F.** Highway and street crossings will be completed in their entirety, including grading, planking, and/or paving in exact accordance with the plans and specifications. Care will be taken to insure the least possible interference with highway or street traffic.
- G.** The horizontal and vertical geometrics of highway crossings require special attention. It must be remembered that highway crossing areas are usually areas that have multiple ownership and that alignments may be dictated by the governmental organization that controls the highway. Vertical Alignment – It is desirable from the standpoint of sight distance, rideability, braking and acceleration, distances at that the crossing be made as level as practicable. Vertical curves should be of sufficient length to ensure an adequate view of the crossing. In some instances, the roadway vertical alignment may not meet acceptable geometrics for a given design speed because of a restrictive topography or limitations of right-of-way. If practical, the crossing surface should be on the same plane as the top of rail for a distance of 30 inches outside the rails. The surface of the highway should also not be more than 3 inches higher or lower than the top of the nearest rail at a point 30 ft from the rail unless super elevation makes a different level appropriate. Tracks that are super elevated or a roadway approach that is not level, require site specific analysis.
- H.** Road crossing construction and rehabilitation is resource intensive and disruptive to rail and highway traffic, therefore special care must be taken to ensure that the crossing is properly installed. The entire "Crossing Zone" requires special care and maintenance practices. The "Crossing Zone" is the crossing surface including all new required pavement and the track and right of way approaching the crossing for 50 feet each side of the crossing.
 - 1. DRAINAGE**
 - a) If the crossing site is well drained and shows no signs of sub-grade problems, extra care must be taken to ensure that drainage facilities are not damaged or improved.
 - b) Good drainage must be provided from all four quadrants of the crossing and crossing zone. Ditches, pipes and/or trench drains should be installed, if necessary, to obtain the adequate drainage.
 - c) A level granular working area must be provided around highway crossing warning devices. If this area is excavated from drainage, it should be filled with free draining ballast. Provisions must be made to protect buried cables. Normally a level area 6 feet to the front/side and 2 feet to the rear of the mast foundation is required for maintenance of gate or flasher mechanisms. Refer to drawing 2613 for details.
 - d) Roadway approaches and ditches should be sloped or diverted away from the crossing.

2. BALLAST

- a) Ballast must be granite or trap rock meeting CSXT Specifications MWI 301, latest revision.
- b) Ballast must be clean and free draining both in cribs and under ties within the crossing.
- c) Ballast within the entire crossing zone must be clean. Ballast that is fouled with mud or debris can degrade the proper operation of crossing warning devices.
- d) Ballast cross section below bottom of tie which supports the track must be compacted solidly before the crossing surface and pavement approaches are placed. Preferred methods of compaction are:
 - i. Vibratory roller
 - ii. Train Traffic (4 tonnage trains or 20,000 tons accumulated minimum)
 - iii. Dynamic Stabilizer with cribs filled with ballast and multiple passes.
- e) The finished ballast cross section in the crossing zone approaching the crossing must comply with Standard Drawing 2602. Care must be taken to ensure that no surplus of ballast is present to impede drainage.

3. CROSSTIES

- a) The old pavement should be saw cut to permit the installation of the track through the roadway. The width of the opening created will vary depending on site conditions and material used (panel installation, 8'-6" vs. 10'-0" ties, etc).
- b) All ties through the entire crossing must be new wood and provide consistent support. Ten foot long wood ties are required for all full width concrete road crossing surfaces.
- c) Crossings in concrete tie territory are to be constructed on 10 foot long wood ties with Positive Restraint Fasteners and Plates. These 10 foot wood ties must extend a minimum of 10 ties beyond each end of crossing as a transition to concrete ties.
- d) During tie installation or track panel construction, the ties will be placed on 19.5 inch centers for rubber interface, timber and concrete crossings. Other manufacturers of crossing surfaces may require ties to be installed at different centers, generally 18 inch.

4. RAIL

- a) No bolted rail joints are allowed in the crossing.
- b) Thermite welds may not be located within the crossing on main tracks and sidings. Thermite welds in the Crossing Zone should be staggered at least 10 feet away from the edge of the crossing.
- c) No bolted rail joints are allowed within the Crossing Zone on main, branch or siding tracks.
- d) Only bonded insulated joints are permitted in the Crossing Zone on main, branch or siding tracks.
- e) Rail anchoring pattern is to be in accordance with MWI 703, latest revision.

5. SURFACING

- a) If practicable in multiple track crossings, all tops of rails should be brought to the same plane.
- b) Solid tamping is important. The tamper must use double insertions and, if capable, tamp the total length of the tie. Care must be taken to avoid center binding of the tie.
- c) When track is tamped, ballast must be compacted before the crossing surface and pavement are placed.
- d) The finished ballast cross section in the crossing zone approaching the crossing must comply with Standard Drawing 2602, latest revision with no surplus ballast to impede drainage.

6. TEMPORARY ROADWAY CROSSING

- a) Ballast & Cold Mix: The quantity and strength must be sufficient to support the expected road traffic. Cold mix must be removed from the track as soon as it is not needed. Ballast must be standard CSXT specification for main track. Other materials are not permitted.
- b) Modular Temporary Crossing: Must be of sufficient size and strength to support the expected road traffic. Modular crossings must be secured with lag screws to prevent movement.

7. ASPHALT PAVING

- a) Asphalt pavement should be full depth between top of tie and road surface except for farm/residential crossings. Compacted pavement must be thick enough to lock into the rubber interface material.
- b) Tack coat must be used where new asphalt meets old pavement. The tack must meet the state DOT specifications for the state in which the crossing is located.
- c) Asphalt (bituminous concrete) pavement used must be a dense graded mix, which meets the state DOT specifications for asphalt pavement construction for the state in which the crossing is located. Certificates must be provided to the ENGINEER.
- d) Asphalt pavement material must be sufficiently hot (minimum 230 degree F) for proper compaction. Optimal temperature is greater than 250 degrees F.
- e) The roller used to compact the asphalt should be a steel wheeled vibratory type. It must be narrow enough to fit between the gage side flangeway interface material and between the outside of the crossing and old pavement. It should exert a minimum force of 12,000 lb/roll at 2400 vpm and operated at a speed of less than 3 ft/sec. normally, a 36 inch vibratory roller will meet these criteria. A roller with equivalent compaction force but less than 26 inch wide must be used between the rails on a Rubber/Asphalt/Timber or Timber/Asphalt type crossing.
- f) The roller must be operated parallel to the rail and up against the rubber, concrete or timber surface material to ensure good asphalt compaction. Use caution not to dislodge rubber interface sections or the clamps/spikes that secure the rubber.
- g) Asphalt should be compacted to at least 91% of maximum theoretical density (air voids less than 5% in the compacted mix). For quality assurance, asphalt core borings may be taken to verify compliance.
- h) Paved road surface should be level with the top of rail for 30 inches from the field side of each rail unless there is a conflict with State regulations. In case of a conflict, the State regulations will govern. For new construction, highway surface should not be more than 3 inches higher or lower than the top of the near rail 30 feet from the rail along the road centerline, unless track super-elevation dictates otherwise. If practicable, slope the pavement 1 inch in 10 feet to meet existing highway surface. On high speed roads, the surface may have to be even smoother to reduce impacts on the crossing surface.

- i) On unpaved roads, the asphalt pavement on the field side of the rail must be of sufficient volume so it does not move or slip away from the rail under the expected roadway traffic. State regulations may require a minimum length apron.
- j) The crossing should be closed to highway traffic long enough for the hot asphalt pavement to cool (hand touchable) and stiffen to support loads without rutting.
- k) Old pavement, ballast, and surface material must be disposed of in a proper manner complying with CSXT policies by the CONTRACTOR.

END OF SECTION 020401

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall furnish and place crushed stone or crushed gravel as shown on CSXT Standard Drawing 2601, latest edition unless otherwise indicated on Project Drawings.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for the item SUBBALLAST will be the number of square yards measured along the surface of the subballast and authorized by the ENGINEER. Subballast installed in excess of the design area shall not be included in the measurement unless authorized by the ENGINEER in writing. Permanent access roads on the plans or as directed by the ENGINEER will be included in the measure. Temporary access roads for the benefit of the CONTRACTOR and construction will not be measured. Note that the CONTRACTOR is to coordinate tolerances of earthwork activities and subballast to obtain a six inch thick layer of subballast. Thicknesses in excess of six inches will not result in increasing the area measurement this item is based on. Obtaining the proper thickness of subballast is a part of this item and critical.
- B. Payment at the unit price bid shall be full compensation for all labor, material, equipment, tools, supplies, and all else necessary to supply, transport, unload, haul, properly place and compact the subballast.
- C. The cost of supplying and applying water to obtain the specified density shall be included in the Bid price.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Subballast shall be composed of crusher run granite or limestone in conformance with the following gradation requirements:

Screen Size	Percent Passing Graded Aggregate	Weight passing Crusher Run
1 1/2"	100%	100%
3/4"	60%-100%	
No. 10	30%-55%	15%-45%
No. 60	8%-35%	
No. 200	5%-20%	5%-12%

- B. CONTRACTOR may substitute the governing DOT material for subbase with similar qualities to the MWI 301 Specification. Material shall be in conformance with DOT specifications in effect at the time of the project bid.
- C. Subballast materials shall be submitted to ENGINEER for approval prior to placing and transporting.

PART 3 - EXECUTION

3.1 EXECUTION

- A. All rutting or displacement of the subgrade shall be smoothed and re-compacted by CONTRACTOR before the placement of any subballast. If the subballast is subject to construction equipment traffic causing displacement or excess compaction, CONTRACTOR shall, at no extra cost to OWNER, bring the sub ballast back to the designated density and grade.

- B.** CONTRACTOR shall not place subballast on a wet, snow covered or icy roadbed.
- C.** Subballast shall be placed in loose lifts of 3 inches and compacted to not less than 95% of its dry weight density as determined by the Modified Proctor Density Test ASTM D 1557. If additional moisture is required to obtain adequate density, then CONTRACTOR shall use water along with approved mixing, shaping and compaction equipment.
- D.** The thickness of the finished subballast shall have a tolerance of plus or minus 0.05 ft to the design thickness. Thickness of subballast shall be monitored throughout construction. Thickness found to be less than tolerance must be corrected by adding additional subballast material. Thicknesses found to be greater than the tolerance can be removed by the CONTRACTOR or left in place.
- E.** The subballast shall be placed with a descending grade of 2% away from the adjacent track in double track territory or away from the centerline in single track territory per standard drawing CSXT 2601, latest revision.

END OF SECTION 020405



PART 1 - GENERAL

1.1 DESCRIPTION

- A. RAILROAD shall purchase all ballast for this project, unless otherwise noted.
- B. CONTRACTOR shall transport, unload, compact and place pre-ballast pads at locations as directed by the ENGINEER. This ballast shall be known as PREBALLAST.
- C. CONTRACTOR shall also transport, unload, and re-handle ballast for turnouts, track shifts, track panels, road crossings, etc. This ballast shall be known as STOCK PILE BALLAST.
- D. If used, CONTRACTOR shall also transport, unload, and re-handle ballast for final ballasting of track. This ballast for the final ballasting will be the same source as STOCK PILE BALLAST but shall be known as FINAL STOCK PILE BALLAST.
- E. RAILROAD shall furnish and transport by rail car ballast for final ballasting to be unloaded and placed by the CONTRACTOR.

1.2 MEASUREMENT AND PAYMENT

- A. Measurement for the item PREBALLAST will be the number of net tons of ballast transported and compacted in place as calculated from weigh tickets provided by CONTRACTOR. CONTRACTOR is responsible to retain weigh tickets and provide ENGINEER copies with invoice.

Measurement for the item STOCKPILE BALLAST will be the number of net tons of ballast transported and placed in stockpiles as calculated from weigh tickets provided by CONTRACTOR. CONTRACTOR is responsible to retain weigh tickets and provide ENGINEER copies with invoice.

Measurement of the item SEPARATION BALLAST & SURFACING shall be measured in track feet where separation is achieved by unloading ballast from railroad cars directly onto sub ballast and raising the track by multiple surfacing passes. This is done in lieu of installation of a pre-ballast pad.

- B. Final ballasting, when RAILROAD furnishes ballast by railcars, shall be considered incidental to track construction. No separate payment shall be made for final ballasting.

Final ballasting, when CONTRACTOR uses FINAL STOCK PILE BALLAST, will be the number of net tons of ballast transported and compacted in place as calculated from weigh tickets provided by CONTRACTOR. CONTRACTOR is responsible to retain weigh tickets and provide ENGINEER copies with invoice

- C. Payment for the item PREBALLAST at the unit price bid shall be full compensation for supplying all labor, designated transportation, materials other than ballast, equipment, supplies, rehandling and storage and all else necessary to unload, transport, re-handle, store, construct pre-ballast pads ballast.

Payment for the item STOCK PILE BALLAST at the unit price bid shall be full compensation for supplying all labor, designated transportation, materials other than ballast, equipment, supplies, re-handling and storage and all else necessary to unload, transport, re-handle, store, ballast stockpiles.

Payment for the item SEPARATION BALLAST & SURFACING at the unit price bid shall be full compensation for supplying all labor, equipment, materials other than ballast, tools, and all else necessary to unload ballast from rail cars onto track structure and surface track to achieve track separation shown on plans (in other words up to the level prior to final surfacing).

Payment for the item FINAL STOCK PILE BALLAST, if used, at the unit price bid shall be full compensation for supplying all labor, designated transportation, materials other than ballast, equipment, supplies, rehandling and

storage and all else necessary to unload, transport, re-handle, store, construct final ballasting. Part 2 - products

2.1 MATERIALS

- A. Ballast shall conform to CSXT's Ballast Specification, MWI-301, latest revision.
- B. Slag material will not be accepted as ballast.

PART 3 - EXECUTION

3.1 EXECUTION – PRE-BALLASTING

- A. The pre-ballast pad will be installed using a spreader box. The width will be as shown on the plans with the entire width of ballast required being added during pre-ballasting. Any excess ballast that fouls the walkway shall be removed at the contractor's expense.
- B. Ballast shall not be spread over snow or ice.
- C. All rutting and pocketing of the ballast (subgrade and sub ballast) shall be corrected by restoring the ballast to a smooth surface.
- D. The ballast shall be placed in loose lifts which are no thicker than 4 inches, and then compacted.
- E. Minimum requirements for ballast compaction are as follows:
 - 1. Compaction equipment shall be a minimum 10 ton vibratory roller capable of generating 1100 to 1500 cycles per minute.
 - 2. Compaction equipment shall be operated as directed by ENGINEER, but in no case shall the speed exceed four (4) feet per second, and the normal operating speed shall be two-and-one-half (2-1/2) feet per second.
 - 3. A minimum of six (6) complete passes with the compaction equipment shall be made over each lift, and each lift shall be compacted until no deformation under load is observed.

3.2 EXECUTION – STOCKPILE BALLAST

- A. Stockpile ballast shall be stockpiled as directed the ENGINEER. Care should be taken to minimize the amount of ballast contaminated on the ground by keeping piles as high as practical.
- B. Excessive ballast contaminated on the ground will be charged back to the CONTRACTOR.

3.3 EXECUTION - FINAL BALLASTING

- A. CONTRACTOR shall place final ballast on the track and uniformly distribute it in sufficient quantities to properly raise the track to the proposed top of rail profile shown on the plans. The ballast shall be placed and the track raised and tamped after the rails are installed, spiked, or clipped in concrete tie sections.
- B. To the extent possible, ballast shall be unloaded in position for use with a minimum of redistribution and dressing. Special ballast cars shall be used when available.
- C. Ballast must be distributed or immediately dressed so that ample clearance is provided for rolling equipment, and so that switches, guard rails, and road crossing flange ways are unobstructed.

- D.** When a pre-ballast pad is not installed, the ballasting of track shall be accomplished in not less than four lifts. Each lift shall not exceed four inches in height, except the final lift shall be approximately two inches in height. When a pre-ballast pad is installed, a minimum of two surfacing passes are required.
- E.** Track cross level shall be maintained, and both rails shall be raised simultaneously when track is being raised.
- F.** Track surfacing shall be done by methods which will prevent undue bending of the rail or straining of the joints. The amount of track lift shall not endanger the horizontal or vertical stability of the track. The track shall be initially raised so that a final raise of not less than one inch nor more than three inches will be required to bring it to finish surface. All ties that pull loose shall be restored to proper position and shall have full bearing against the rail and be properly secured to the rail.
- G.** The track shall be placed in proper alignment when initially raised and tamped. The final alignment of track shall be done with a production type tamper capable of meeting the design specifications. The grades and alignments of each complete track shall conform to the design shown on the plans. The grade rail on all curves shall be the inside rail of the curve. After the track has been tamped, CONTRACTOR shall neatly dress the ballast and add or remove quantities of ballast as required to conform to CSXT Standard Drawing 2602 unless otherwise indicated on the Project Drawings. Surplus ballast shall be stockpiled at the direction of ENGINEER.
- H.** Tamping of ballast shall be done with power tamping equipment. Control or cycling of the power tamper shall provide the maximum proper compaction of the ballast uniformly along the track. The ballast shall be thoroughly tamped on both sides of the tie from a point 15 inches inside the rails to the ends of the ties.
- I.** When the track has been raised to within two inches of the final grade and properly compacted, a finishing lift shall be made by jacking the track to the finish top-of-rail elevations. The ballast shall then be applied under the ties for their entire length and thoroughly driven in place for a space extending from fifteen inches inside either rail to the ends of the ties, by tamping machines, tamping picks, or tamping bars. The ballast under the remainder of the tie bearing shall not be tamped. In making the finishing lift, the spot board and track level board shall be used with care and the track brought to a true surface with the required superelevation of the outer rail on spirals and curves.
- J.** After the track has been brought to true surface, elevation, and grade, it shall be given a final lining conforming to the established track center. Every effort shall be made to maintain approximate line during preliminary ballast applications.
- K.** After the track has been finally surfaced and lined, the ballast shall be dressed to conform to the standard sections shown on CSXT Standard Drawings. CONTRACTOR shall provide the necessary templates for shaping the ballast sections. The edge of ballast shall be brought to true line by means of shovels, forks or ballast regulating machine, and the ballast shoulders shall be uniformly formed and compacted. All excess ballast shall be removed and deficiencies of ballast shall be supplied.
- L.** CONTRACTOR shall neatly dress the ballast and add or remove quantities of ballast as required to provide a uniform appearance that conforms to the typical section or to CSXT standard plan, after the track has been tamped. Surplus ballast shall be stockpiled at the direction of ENGINEER.
- M.** If CONTRACTOR contaminates the ballast with foreign material, then CONTRACTOR shall replace and re-compact the contaminated ballast. CONTRACTOR shall re-compact all previously compacted ballast which is disturbed.

END OF SECTION 020410

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. CONTRACTOR shall field survey and stake the proposed horizontal and vertical track alignments. The alignments shall be the same as those shown on the plans.
- B. Staking shall be done a minimum of two times: Once after the subballast has been placed to ensure that the subballast has been placed in compliance with the plans; and again after final ballasting to ensure that the track has been placed in compliance with the plans.

1.2 MEASUREMENT AND PAYMENT

- A. No measurement or payment item will be provided for work under this section. Work is considered incidental to the construction of the track and roadbed.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Track work control points shall be offset and protected by CONTRACTOR. Lost or destroyed survey reference points, bench marks, and control points shall be restored by CONTRACTOR.
- B. Field staked points shall be a hard wood hub with a tack, or a center punched iron pin. Stakes shall be driven into the ground or ballast a minimum of 12 inches and shall not be easily disturbed.
- C. Tangent track and curves flatter than 5 degrees shall be staked along the centerline of track at intervals of 50 feet or less.
- D. Track with curves of 5 degrees or sharper shall be staked along the centerline of track at intervals of 25 feet or less.
- E. Tracks with super elevation shall have their profile or vertical alignment follow the low rail. The low rail shall be the inside rail of the curve
- F. Superelevation and Spirals shall be governed by CSXT standard procedure MWI 1104, latest revision.
- G. All turnouts must be staked on the centerline of track at the point of switch (PS), turnout point of intersection (PI), and half inch point of frog (PF).
- H. Crotched turnouts shall be staked as described for all turnouts, and also as described for track on curves.
- I. The top of rail elevation shall be set to within 0.01 feet of the designed profile elevation shown on the plans.
- J. Horizontal control points shall be set to within 0.01 feet of the coordinates shown on the plans.
- K. CONTRACTOR shall station existing track, mark web of rail using paint stick.

END OF SECTION 020415

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Division 7: Structures

100 Series: Material

070105	Concrete	June 11, 2018
070110	Grout	June 11, 2018
070120	Reinforcing, Prestressing and Post-Tensioning Steel	June 11, 2018

200 Series: Incidental Construction

070205	Temporary Structure/Falsework	June 11, 2018
070210	Structure Excavation – Cofferdams, Sheeting & Shoring	June 11, 2018
070220	Demolish and Remove Existing Structure	June 11, 2018

070265	Flowable Fill	June 11, 2018
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300 Series: Miscellaneous Construction

070305	Retaining Walls	June 11, 2018
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400 Series: Bridge Substructure

070405	Pile Sockets	June 11, 2018
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PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section covers material specifications for all types of Portland Cement Concrete, fabrication requirements for precast/prestressed concrete, and construction requirements for cast-in-place concrete elements used on CSX Transportation bridge construction projects.

1.2 ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

AASHTO.....	American Association of State Highway and Transportation Officials
ACI.....	American Concrete Institute
ANSI.....	American National Standards Institute
AREMA.....	American Railway Engineering and Maintenance of Way Association
ASCC	American Society of Concrete Contractors
ASCE.....	American Society of Civil Engineers
ASTM.....	American Society for Testing and Materials International
ESCSI.....	Expanded Shale, Clay and Slate Institute
FHWA	Federal Highway Administration
ISO	International Standards Organization
LWA.....	Lightweight Aggregate
LWC.....	Lightweight Concrete
MRE	Manual of Railway Engineering (Published by AREMA)
NRMCA	National Ready Mixed Concrete Association
NSSGA.....	National Stone, Sand & Gravel Association
PCA.....	Portland Cement Association
PCI.....	Precast/Prestressed Concrete Institute
SCC	Self-Consolidating Concrete
USACE.....	U.S. Army Corps of Engineers
BUILDER.....	Either CSXT company forces or the CONTRACTOR
CONTRACTOR.....	The business entity contracted by CSXT for construction of the project
ENGINEER.....	The CSXT Assistant Chief Engineer – Structures or designated representative
RAILROAD	CSX Transportation (CSXT)

PART 2 - MATERIAL

2.1 CEMENT

- A. Cement, unless otherwise specified, shall conform to the following:

1. Standard Concrete – Cement shall be Type I, Type IA, or Type II Portland cement, conforming to the requirements of ASTM C150.
2. High Early Strength Concrete – Cement shall be Type III or Type IIIA Portland cement, conforming to the requirements of ASTM C150.
3. Air-Entrained Concrete – Cement shall be Portland cement conforming to the requirements of ASTM C150 and ASTM C595;

The cement shall have an alkali content of 0.6% or less, expressed by percent Na_2O plus 0.685 percent K_2O by mass of the cement. Only one brand of cement may be used in any part of the structure and cements of the same brand from different mills shall not be mixed or used in any part of the structure, except as permitted by the ENGINEER

- B. Slag Cement shall not be used. Silica fume and fly ash shall not be used to reduce the quantity of Portland cement. Fly ash (all Classes) is prohibited in concrete for CSXT unless approved by the ENGINEER.
- C. All cement shall be inspected and tested by a Testing Laboratory employed by the RAILROAD. Where the CONTRACTOR furnishes the cement, the name and address of the Testing Laboratory will be furnished by the ENGINEER. The CONTRACTOR shall specify in their order to the manufacturer that the cement is to be so inspected and tested, and shall advise of the name and address of the Testing Laboratory. The CONTRACTOR shall also write the Testing Laboratory, stating location of the project, number of barrels of cement involved and the name and location of this mill, sending a copy of that letter to the ENGINEER.

2.2 AGGREGATES

- A. Fine Aggregate – Fine aggregate shall consist of coarse, sharp, hard, strong, durable, fine aggregate of natural sand, free from adherent coating, and washed to remove clay, loam, alkali, organic matter or other deleterious substances.

1. Fine Aggregate Grading Requirements - Grading shall be in accordance with AREMA recommendations.

- a. Fine aggregate shall be graded from coarse to fine within the following limits:

<u>Sieve</u>	<u>Percentage Passing</u>
¾ inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

SCC should contain a designed percentage of microfine aggregate (powder) to provide adequate workability of the mix. Workability of SCC must be considered and designed for each specific application.

- b. The fine aggregate shall have not more than 45% retained between any two consecutive sieves, and its fineness modulus shall be not less than 2.3 nor more than 3.1. Fineness modulus is the summation of the cumulative percentages retained on standard sieve sizes (Nos. 4, 8, 16, 30, 50 and 100) divided by 100.
- c. If the fineness modulus varies by more than 0.20 from the value assumed in selecting proportions for the concrete, the fine aggregate shall be rejected unless suitable adjustments are made in the concrete proportions to compensate for the difference in grading.
2. Lightweight Fine Aggregate – Lightweight fine aggregate shall consist of crushed lightweight coarse aggregate meeting the size, soundness, reactivity, and other requirements of normal weight fine aggregate.
3. Required Tests and Test Limits – The amount of clay or loam in the fine aggregate shall not exceed 1.5% by weight. Unless otherwise specified, all fine aggregate shall conform to the requirements of ASTM C33. Particular attention is directed to the requirements of testing for:
- a. Organic Impurities – ASTM C40
- b. Soundness – ASTM C88
- c. Reactivity – ASTM C289
4. Deleterious substances shall not be present in excess of the following amounts:

<u>Item</u>	<u>Maximum Percent by Weight of Total Sample</u>
Clay lumps	1.0
Material finer than No. 200 sieve:	
Concrete subject to abrasion.....	3.0
All other concrete	5.0
Coal and lignite	0.5
The sum of all deleterious	5.0

5. The fine aggregate, when tested in accordance with ASTM C40 and showing a color darker than the standard color, shall be rejected. A fine aggregate failing in the test may be used, provided that, when tested for mortar- making properties, the mortar develops a compressive strength at 7 and 28 days of not less than 95 percent of that developed by a similar mortar made from another portion of the same sample which has been washed in a 3 percent solution of sodium hydroxide followed by thorough rinsing in water. The treatment shall be sufficient to produce a color lighter than standard with the washed material.
 6. For SCC, the volume ratio of fine to total aggregates in a mix design must be greater than or equal to 45% unless approved by the ENGINEER.
 7. Other – Fine aggregate considered potentially reactive by the ENGINEER shall not be used. Fly ash, if approved by the ENGINEER to supplement fine aggregate, shall meet the requirements of ASTM C618.
- B. Coarse Aggregate –** Coarse aggregate shall consist of hard, durable, crushed stone or gravel.
1. Coarse Aggregate Grading Requirements – Coarse aggregate shall be graded between the limits specified and conforming ASTM C33 for Coarse Aggregate.

Aggregate Size No.	Amounts Finer than Each Laboratory Sieve, Mass Percent								
	2½ in.	2 in.	1½ in.	1 in.	¾ in.	½ in.	⅜ in.	No. 4	No. 8
357	100	95-100		35-70		10-30		0-5	
467		100	95-100		35-70		10-30	0-5	
57			100	95-100		25-60		0-10	0-5
67				100	90-100		20-55	0-10	0-5

Note: For SCC, the maximum size of the coarse aggregate shall not exceed 1 inch.

2. Lightweight Coarse Aggregate – The nominal size of lightweight coarse aggregate shall be ¾ inch. Lightweight coarse aggregate shall be expanded slate lightweight aggregate (LWA). Lightweight aggregate shall have a minimum absorbed water content of 6% by weight at the time of batching.
3. Required Tests and Test Limits – Sampling and testing shall be in accordance with the following ASTM standards:
 - Sampling ASTM D75
 - Sieve Analysis..... ASTM C136
 - Weight of Aggregates ASTM C29
 - Resistance to Abrasion..... ASTM C131 and C535
 - Soundness ASTM C8
 - Material Passing No. 200 Sieve ASTM C117
 - Organic Impurities ASTM C40
 - Coal and Lignite..... ASTM C23
 - Clay Lumps in Aggregates ASTM C142
 - Specific Gravity and Absorption of Coarse Aggregate ASTM C127
 - Potential Alkali Reactivity ASTM C289
4. Deleterious substances shall not be present in excess of the following amounts:

<u>Item</u>	<u>Maximum Percent by Weight of Total Sample</u>
Clay lumps and friable particles	5.0
Chert that will readily disintegrate (soundness tests, five cycles).....	5.0
Material finer than No. 200 sieve.....	1.0
Coal and lignite.....	0.5
The sum of all deleterious substances	7.0

When the material finer than the No. 200 sieve consists essentially of crusher dust, the maximum amount permitted may be raised to 1.50%

5. Crushed stone or gravel tested for abrasion in the Los Angeles machine in accordance with ASTM C131 and C535 shall have a loss not greater than 50% except that aggregates for pavements shall have a loss not greater than 40%.
 - a. The aggregates, when subjected to five alternations of the sodium-sulfate soundness test, shall show an average loss of weight of not more than 8% for fine aggregate and 12% for coarse aggregate. Aggregates having a potential alkali reactivity as determined by ASTM C289 shall not be used.

2.3 WATER

- A. General – The water for use with cement in mortar or concrete shall be potable, clean, clear, and free from oil, acid, alkali or organic matter and shall be obtained from a suitable source.
 1. Water for mixing or curing concrete shall be fresh, clean, and free from injurious quantities of acid, alkali, silt, oil, organic matter, or other impurities;
 2. Water for use in concrete shall not be taken from shallow, muddy or marshy surfaces. Water from suspect sources shall not be used until tested and approved in accordance with ASTM C1602. In cases where sources of supply are relatively shallow, they shall be so enclosed as to exclude silt, mud, grass, etc., and the bottom of such enclosed area shall be maintained not less than 2 feet below the intake of the suction pipe;
 3. When required by the ENGINEER, samples of water shall be sent to a Testing Laboratory employed by the Railroad, for analysis to determine the suitability of the water for use in concrete.

2.4 CHEMICAL ADMIXTURES

- A. Air-Entraining Admixtures
 1. Testing requirements – conform to ASTM C260. Air content of both normal weight concrete and lightweight concrete shall be tested in accordance with ASTM C173.
 2. Dosage – Air content can vary from 3% to 7% in concrete for CSXT bridges including SCC. For lightweight concrete, air content shall be between 5% and 7%. For Lightweight Concrete - Concrete shall be air-entrained by the use of an air entraining admixture conforming to requirements of ASTM C260, or by the use of air-entraining Portland cement meeting the requirements of ASTM C150. The concrete shall have an air content of between 5% and 7%.
- B. Normal, Mid-Range and High-Range Water Reducing Admixtures
 1. Testing requirements – Normal and Mid-Range water reducers shall conform to ASTM C494. High-Range water reducers shall conform to both ASTM C494 and ASTM C1017.
 2. Dosage – Normal water reducers can reduce water content by 5% to 10%. Mid-Range water reducers can reduce water content by 6% to 12%. High-Range water reducers (also known as superplasticizers) can reduce water content by 12% to 40%. All SCC shall be formulated with high-range water reducer.
- C. Set Accelerating Admixtures
 1. Testing requirements – conform to ASTM C494, Type C.
 2. Dosage – Set accelerating admixtures incorporating calcium chloride shall not be used in concrete for CSXT bridges. Set acceleration varies with dosage rate. Acceptance tests shall be made with actual job materials under anticipated job conditions before use.
- D. Set Retarding Admixtures
 1. Testing requirements – conform to ASTM C494.
 2. Dosage – Acceptance tests shall be made with actual job materials under anticipated job conditions before use.
- E. Hydration Control Admixtures
 1. Uses:
 - a. Suspending cement hydration – stops hydration for up to 72 hours.
 - b. Reactivating cement hydration – reestablishes normal hydration.

2. Testing requirements – no ASTM specification
 3. Dosage - Acceptance tests shall be made with actual job materials under anticipated job conditions before use.
- F. Concrete Workability Admixtures**
1. Testing requirements – Admixtures shall conform to ASTM C494, Type S.
 2. Dosage - Acceptance tests shall be made with actual job materials under anticipated job conditions before use.
- G. Coloring Admixtures**
1. Testing requirements – Admixtures shall conform to ASTM C979.
 2. Dosage – less than 6% by weight generally does not affect other concrete properties. Greater than 10% by weight shall not be used in CSXT concrete for bridges.
- H. Other Admixtures:** The CONTRACTOR may propose other admixtures depending on site conditions and use of the concrete, subject to approval by the ENGINEER.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. Submittals:** The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records, each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER.
1. Preconstruction Submittals
 - a. Concrete mix design, including historical test data or trial batch test data
 - b. Concrete test analysis and summary
 - c. Material certifications
 - d. Admixtures
 2. Additional Submittals for Cast-in-Place Concrete: All drawings, details and calculations shall be signed and sealed by a Professional Engineer licensed in the Commonwealth, District, State, or Province where the work is to be performed.
 - a. Forms and Falsework design and details
 - b. Cold Weather Placement Plan
 - c. Hot Weather Placement Plan
 - d. Slump Tests – A record of the amount of slump shall be made and furnished to the ENGINEER.
 - e. Strength Tests – The test results shall be furnished directly to the ENGINEER in writing, by the Testing Laboratory, on a standard testing report form.
 3. Additional Submittals for Precast/Prestressed Concrete: All drawings, details and calculations shall be signed and sealed by a Professional Engineer licensed in the Commonwealth, District, State or Province where the work is to be performed.
 - a. Material Submittals for all related components/accessories.
 - b. Detailed computations of proposed gauge pressures and elongations (if required).
 - c. Permanent records of elongation and pressure readings during stressing operations (if required).
 - d. For on-line installation of precast concrete superstructure elements, the CONTRACTOR shall submit a detailed plan with schedule, for review and approval, prior to span change out.
 4. Shop Drawings: CONTRACTOR shall furnish one (1) complete electronic copy of detailed shop drawings for approval prior to starting fabrication. By approving and submitting shop drawings, the CONTRACTOR thereby

represents that all field measurements, field construction criteria, materials, catalog numbers and similar data have been determined and verified, and that the shop drawings have been checked and coordinated with the requirements of the work and of the contract documents. After approval of shop drawings, the CONTRACTOR shall supply the RAILROAD one (1) complete electronic set of reproducible approved drawings.

5. Final acceptance report.
- B. Submittal Review: Approval by the ENGINEER is only for the purpose of confirming compliance with the contract plans and specifications. Approval shall not relieve the CONTRACTOR from responsibility for correctness, quantity and quality, nor for completeness of Work in accordance with the plans and specifications.

PART 4 - EXECUTION

4.1 CONCRETE STRENGTH, PROPORTIONS AND CLASSES

- A. General: The use of fly ash as a substitute for Portland cement is prohibited in all concrete for use in CSXT bridges.
- B. Concrete Classes:

Class of Concrete	Min. Comp. Strength at 28 Days (PSI)	Max. Total Water per 94 lb. Sack of Cement (gals.)	Cement Factor: Min. Sacks of Cement per Cubic Yard of Concrete
8.5 (AE)	8,500	*	*
6 (AE)	6,000	*	*
5	5,000	5.0	7.0 Min. 8.0 Max.
5(AE)	5,000	4.0	7.0 Min. 8.0 Max.
4	4,000	6.0	6.0
4(AE)	4,000	5.5	6.0
3	3,000	6.5	5.5
3(AE)	3,000	5.75	5.5

(AE) denotes air-entrained concrete.

* Water and Cement Factors for Class 8.5 and Class 6 shall be proposed by the supplier and subject to approval by the ENGINEER.

4.2 TESTING REQUIREMENTS

- A. Pre-construction Testing: The CONTRACTOR shall submit the proposed concrete mix design to the ENGINEER. After receiving approval for the mix design, the CONTRACTOR shall furnish a two (2) CY batch of concrete for the sole purpose of making test specimens. The CONTRACTOR shall make a minimum of eight (8) standard test cylinders and deliver them to an independent laboratory which shall conduct tests at 7, 14, and 28 days. No concrete shall be placed until satisfactory compressive strength for the mix design has been documented through the test results. Substandard shall mean anything less than the minimum compressive strength at 28 days as specified above, for that class of concrete. No reductions or tolerances will be recognized, regardless of ACI or other Association Standards for acceptance.
- B. Testing During Fabrication of Precast Elements: For prestressed concrete, eight (8) standard test cylinders shall be made each day for each production line. Two (2) cylinders shall be used to determine the time after placing of concrete when stress may be released. Two (2) cylinders each shall be broken at 7 and 28 days. The two (2) remaining cylinders are to be used for determining stress release in case that the concrete has not attained required strength on the first two cylinders. When steam curing is used, the 7 day test may be omitted. Heavy steel molds with steel bottoms shall be used for the test cylinders and the CONTRACTOR shall furnish the cylinders and the labor to secure the samples.

C. Construction Testing:

1. Slump Testing – Slump shall not exceed 3 inches for cast-in-place concrete. Slump shall not exceed 9 inches for precast concrete elements. At least one (1) slump test shall be made for each concrete element or 15 cubic yards of concrete placed in the structure.
2. Strength Testing – Compression tests will be required as specified in the AREMA recommendations. The CONTRACTOR shall furnish all test materials and test cylinder molds, shall perform all work to make and cure the test cylinders, and after proper curing, shall deliver the test cylinders to an independent testing laboratory where they shall be tested at the CONTRACTOR's expense. Not less than eight (8) test cylinders shall be made for each 20 cubic yards of concrete or for each precast element if such elements are poured on separate days. Two cylinders at each test date of 7, 14, and 28 days shall be delivered to an independent laboratory for testing. Spare cylinders shall be provided.

No concrete elements shall be placed in the permanent structure until satisfactory compressive strength for the mix design has been documented through the test results. Any concrete placed in the permanent structure for which test cylinders indicate substandard compressive strength shall be removed and replaced at expense of the CONTRACTOR. Substandard shall mean anything less than the minimum compressive strength at 28 days as specified above. No reductions or tolerances will be recognized, regardless of ACI or other Association Standards for acceptance.

D. Testing for Self-Consolidating Concrete (SCC):

1. The following tests shall be performed for SCC at 15 minute intervals following mixing and during placement to monitor the workability of the SCC.
 - a. Slump Flow Test: For SCC the slump test shall be replaced by the slump flow test, in accordance with ASTM C1611. For SCC, the slump flow value shall be 27.0 inches with an allowable tolerance of plus or minus 2.5 inches. The T_{50} shall be recorded. T_{50} shall be greater than 2 seconds.
 - b. Visual Stability Index (VSI): The VSI rating shall be determined in accordance with ASTM C1611 and shall not exceed 2.0. Perform a second test when the VSI of the first test exceeds a value of 2.0. The proposed mix shall be rejected if the second VSI test exceeds a value of 2.0.
 - c. Passing Ability of SCC by J-Ring: The J-Ring test shall be performed in accordance with ASTM C1621. The calculated difference between slump flow and J-Ring flow shall not exceed 2 inches.
 - d. Static Segregation of SCC using Column Technique: The maximum allowable static segregations shall be 15% as determined by ASTM C1610.
2. Strength Testing: Modify the consolidation method of the strength tests by placing the concrete in the test molds in one layer without vibration or tamping. SCC shall meet the same requirements for strength as those required for non self-consolidating concrete.
3. Other Tests – All other testing of SCC shall be in accordance with the requirements of this Section for testing of the class of concrete specified for the project. Trial batches of SCC shall be made with the same equipment and materials as those to be used for the project, and under similar conditions.

4.3 MASS CONCRETE

- A. Definition – Mass concrete requires measures to be taken to deal with the generation of heat from the hydration of the cement. In mass concrete the temperature differential between the internal concrete temperature and the surface concrete temperature may cause volume changes in the concrete which then cause cracking. Where the minimum cross section dimension exceeds four feet, concrete shall be designated as mass concrete. However, smaller sizes may also be designated as mass concrete depending on factors including: type and quantity of cement, volume-to-surface ratio of the concrete, weather conditions, concrete placing temperatures, degree of restraint to volume changes and the effect of thermal cracking on function, durability and appearance.
- B. Designation – Mass concrete placements shall be designated on the project drawings by the designer.
- C. Additional Requirements.
 1. The maximum temperature in concrete after placement shall not exceed 158° F.

2. The maximum temperature difference between center, or hottest portion of the concrete, and the surface of the placement shall not exceed 35° F, unless thermal modeling is performed to determine a maximum allowable temperature difference such that thermal stresses do not exceed the tensile strength of the concrete. The thermal model shall be signed and sealed by a Professional Engineer licensed in the Commonwealth, District, State or Province where the work is to be performed.
 3. The temperature of concrete at point of placement shall not exceed 70° F nor be less than 35° F.
 4. ASTM C150 Type III cement is not permitted
 5. Accelerating admixtures shall not be used unless specifically permitted by design.
 6. Unless otherwise specified, cool the concrete gradually so that the drop in concrete surface temperature during or at the conclusion of the specified curing period does not exceed 20° F in any 24 hour period.
- D.** Thermal control –Thermal control measures shall be submitted in writing and be approved by the ENGINEER prior to placing mass concrete. Thermal control shall be in accordance with ACI 207.1R.

4.4 FORM AND FALSEWORK PLACEMENT FOR CAST-IN-PLACE CONCRETE

- A.** Strength: The CONTRACTOR shall provide falsework and forms adequate in strength to support the imposed loads safely and without excessive deformation or settlement. Forms and falsework shall be designed for minimum lateral pressures from a fluid weight of 50 lbs. per square foot. In addition, forms for all substructure units are to be watertight. All formwork for SCC shall be watertight and checked for leaks before placing concrete. Formwork for SCC shall be designed for the full fluid weight of the concrete.
- B.** Surface: Forms shall be adapted to the kind of surface required on the concrete; shall be substantially and tightly built so as to remain true to line and in position without bulging, sagging or other deformation. Forms shall be maintained in a manner that will prevent the formation of joints due to shrinkage of lumber.
- C.** Chamfers / Bevels: Chamfers or bevels on concrete members shall be formed by one of two methods. If the Plans call for a bevel having a dimension of the square side greater than four inches, it shall be formed with the same type of form lining used for adjacent forms. However, if the dimension required is less than four inches, the bevel shall be formed with a wooden, triangular 45 degree chamfer strip. The chamfer strip shall be shaped in a planing mill, shall be surfaced on all sides, and shall have uniform dimensions throughout its length. Other materials such as plastic, vinyl or metal may be used, and shall conform to similar surfacing requirements.
- D.** Edges / Corners: Unless otherwise indicated on the Plans, all exposed concrete edges and corners which are sharper than 90 degrees shall be formed with a wooden chamfer strip, meeting the foregoing requirements, except that the dimensions of the square sides of the chamfer strip shall be not more than one (1) inch or less than ¾ inch.
- E.** Plywood Forms: Forms for concrete surfaces which will be exposed to view shall be made of plywood not less than 5/8 inch thick or plywood lining on one-inch boards. Plywood forms or plywood-lined forms shall be sanded on the face adjacent to the concrete. Joints in plywood panels shall be carefully fitted to reduce form marks in the concrete to a minimum. Sections of forms to be reused on concrete exposed to view shall be thoroughly repaired, replacing any plywood that has warped or bulged. Offsets at abutting panels shall be eliminated by renailing and planing. Metal plates shall not be used for covering old form rod holes.
- F.** Metal Forms: Metal forms may be used, provided they are maintained in good condition, free from dents, deformities and misalignment, and provided the finished concrete surface is equivalent in appearance to that obtained through the use of plywood forms. If wood forms are used in combination with metal forms, the wood shall be treated in a manner which will produce a finished surface similar to that produced by the metal forms.
- G.** Steel Rods: Steel rods shall be used for form ties. Rods may be embedded in the concrete, provided their ends are not closer to the surface than one (1) inch, and the holes left by removal nuts shall be filled and pointed. Mortar for pointing and filling holes shall have the same proportions of cement and sand as the concrete.
- H.** Plywood Form Sealer: All forms shall be thoroughly drenched with water immediately before the concrete is placed therein. Wooden forms for concrete exposed to view shall be sealed with a copolymer resin “Pre-Form”, which shall meet the following criteria: US Army Corps of Engineers CEGS-03300, Section 10.8 Form Coating, V.O.C. compliant, and 100% biodegradable. Submit technical datasheet to ENGINEER for compliance.
- I.** Formwork Removal: Before the removal of forms, concrete shall have attained sufficient strength to endure such removal without being damaged. Forms shall be removed carefully so that neither the forms nor the tools used in their

removal will deface the concrete. Unless noted otherwise or as directed by the ENGINEER, falsework shall not be removed until such time as the concrete supported by it is able to sustain itself and any load that is likely to come upon it with absolute safety to the concrete. In general, side forms carrying no loads may be removed after 24 hours. In all cases, the CONTRACTOR is responsible for and must repair at his/her own expense, any damage arising from inadequate forms or falsework, or from the premature removal of same.

4.5 REINFORCING STEEL PLACEMENT

- A. CONTRACTOR shall, before proceeding with the work, field check all dimensions, and submit for review a complete set of any necessary shop drawings. No work shall be done until the shop drawing review is completed. In case of correction or rejection, the contractor shall revise and resubmit the drawings until they are acceptable to the engineer and such procedure will not be considered as a cause for delay.
- B. Fabrication: Reinforcing bars shall be detailed and fabricated in accordance with AREMA recommendations.
- C. Splicing: Reinforcing bars shall be cut to the lengths indicated on the Plans or longer as approved by the ENGINEER. Splices which are permitted, unless otherwise shown on the Plans, shall be designed in accordance with applicable AREMA recommendations. Where practicable, the locations of the laps shall be staggered so the neighboring bars will not have adjacent laps. Mechanical splices are not permitted unless approved by the ENGINEER. If approved, the mechanical splice shall fully develop the strength of the reinforcing bar, and shall be certified by the manufacturer.
- D. Placing: Reinforcement shall be placed accurately in the position indicated on the Plans and shall be firmly held in place during the deposition and vibration of the concrete. This shall be accomplished by fastening the bars at all intersections and splices by wires or approved clips, by the use of bars or other suitable spacers, or as otherwise approved by the ENGINEER. Suitable supports of approved number and character shall be used to support and retain the reinforcement in the locations required and at proper distances from the forms. If such supports are to be left in place in the concrete, they shall be of metal and all parts of such metal supports extending to within one inch of what will be an exposed concrete surface shall be galvanized.
- E. Grouting: Reinforcing bars grouted into existing concrete and / or masonry as shown on the Plans will be grouted using a 2-compound epoxy. The method of mixing and application shall be as recommended by the manufacturer.

4.6 CAST-IN-PLACE CONCRETE PLACEMENT

- A. Minimum strength: Concrete for cast-in-place reinforced concrete shall have a minimum 28-day strength per the project plans.
- B. Consistency: The consistency of the concrete shall be kept as uniform as practicable. Concrete shall not be placed until the ENGINEER is satisfied that the rate of producing and placing concrete will be sufficient to complete the proposed pour and the finishing operations within the scheduled time, that experienced concrete finishers will be employed to perform all required finishing work, and that all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.
- C. Retarding Admixture: Concrete shall be placed in the forms immediately after each mixing. If concrete cannot be placed in forms within sixty (60) minutes from the time water is first added to the mix, a retarding admixture may be added at time of mixing, provided the ENGINEER approves each such use in advance. The admixture must be used in strict accordance with the manufacturer's instructions. In no case shall concrete be used which does not reach its final position in the forms within ninety (90) minutes after the time that water is first added to the mix. The method and manner of placing shall be such as to avoid the possibility of segregation of the aggregates or the displacement of the reinforcement. Sufficient capacity of placing equipment and manpower shall be provided so that the work may be kept free from cold joints.
- D. Conveyance of Wet Concrete:
 - 1. Pumped Concrete: Concrete shall be pumped when chutes, troughs or pipes are impractical, or at the discretion of the CONTRACTOR.
 - 2. Tremie: The tremie method shall be used for placing concrete in pipe piles, under water, deep walls and other locations where concrete would drop greater than six (6) feet. The tremie tube shall have a minimum diameter of 8 inches, and be constructed in sections having water-tight joints. Ensure that the discharge end is entirely immersed in concrete at all times during delivery and keep the tremie tube full until delivery is complete. The tremie tube may be supplied by pumped concrete or the traditional hopper method. If the hopper method is used, ensure

delivery of fresh concrete to the hopper is a consistent, uninterrupted flow. Avoid intermittent large placements into the hopper which would vary the pressure.

- E. Continuous placement: Unless otherwise directed by the ENGINEER, placing of concrete shall continue regardless of weather conditions, and the CONTRACTOR shall be prepared to continue operations without cessation through completion.
- F. Reinforcing Steel: Reinforcing steel shall meet the requirements of Section 070120 of the CSX Design and Construction Standard Specifications.
- G. Layering: Mass concrete or large volume placements shall be placed in horizontal layers, the thickness of which generally shall not exceed ten (10) to twelve (12) inches. The placing of concrete shall be continuous until completion of the substructure unit. Construction joints in addition to those provided on the plans will not be allowed unless authorized by the ENGINEER. When it is necessary by reason of an emergency, to place less than a complete horizontal layer at one operation, such layer shall terminate in a vertical bulkhead. In any given layer, the separate batches shall follow each so closely that each one shall be placed and compacted before the preceding one has taken initial set, in order that the green concrete shall not be injured and that there shall be no line of separation between batches. Each layer of concrete shall have an amplitude of 3/8" to secure efficient bonding with the next layer above. A succeeding layer placed before the underlying layer has become set shall be compacted in a manner that will entirely break up and obliterate the tendency to produce a construction joint between the layers. Layers completing a day's work or placed just prior to temporarily discontinuing operations shall generally be cleaned of all objectionable material as soon as the surface has become sufficiently firm to retain its form. To avoid, as far as possible, visible joints upon exposed faces, the top of the concrete adjacent to the forms shall be finished by being smoothed with a plasterer's trowel. Horizontal layers so located as to produce a construction joint at a location where a "feather edge" might be produced in the succeeding layer, shall be so formed by inset formwork that the succeeding layer will end in a body of concrete having a thickness of not less than six (6) inches. Between levels of extreme low water and extreme high water as determined by the ENGINEER, water shall not come in direct contact with the concrete for a period of not less than 30 days. Water shall not be allowed to come in contact with other concrete that will be in or exposed to water until it is hardened for at least four (4) days. Concrete may be deposited in water only when so approved by the ENGINEER.
- H. Compaction: Concrete shall be compacted by continuous working with suitable tools in a manner acceptable to the ENGINEER. All faces shall be well spaded and the mortar shall be flushed to the surface of the forms by continuous working with a concrete spading implement acceptable to the ENGINEER.
- I. Vibrators: During placement of all concrete, the CONTRACTOR shall furnish power-driven vibratory tools of an approved character, which shall be thrust into the concrete and operated internally in accordance with the best accepted practice. Vibrators shall not be applied to forms or reinforcing steel. The vibrators shall operate at a minimum frequency of 4,500 impulses per minute. The number of vibrators in operation for the various parts of the structure and extent of operation shall meet the approval of the ENGINEER. Concrete shall be thoroughly and completely vibrated, not merely worked down to a horizontal surface. However, precautions should be taken not to over-vibrate to the point that segregation results.
- J. Embedded Steel Plates and Angles, Steel Connectors: Embedded steel plates and angles, and fabricated steel connector assemblies shall conform to the structural steel requirements of Section 070125 of the CSX Design and Construction Standard Specifications. Such metalwork shall be accurately positioned and securely held in place during concrete placement wherever it is required to be built into the concrete. The concrete shall be deposited with care to prevent honeycomb or other defects in the concrete adjacent to the embedment. Where necessary, bolts and other parts shall be supported by accurate templates until the concrete has set.
- K. Construction joints: Construction joints shall be placed as indicated on the Plans or as directed by the ENGINEER and shall be formed so as not to impair the strength or appearance of the structure. When the work of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. The method and manner of placing concrete shall be so regulated as to place all construction joints across regions of low shearing stress and in such location that they will be hidden from view to the greatest possible extent. The method and sequence of placing concrete shall be as specified herein for the particular type of construction involved.
- L. Finishing Operations: Concrete shall be placed at such a time that finishing operations can be completed during daylight hours unless adequate lighting facilities are provided by the CONTRACTOR, and the ENGINEER's approval is given.

- M. Concrete Finish:** The upper surface of the piers and abutments which are not formed shall be given a float surface finish, except as noted below for bearing surfaces. The bearing seats on the caps and abutments shall be thoroughly worked and floated by hand with a wooden float to leave a fine, clean, smooth, sandy texture. Bearing areas shall be ground level. Top surfaces of substructure units, not covered by bearing pads, shall be sloped to drain as shown on the Plans.
- N. Concrete Face:** Special care shall be taken to work the coarser aggregate back from the face and to force the concrete under and around the reinforcement bars without displacing them. After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcement.
- O. Logo, and Date:** The CONTRACTOR shall cast the CSX logo and the year of construction in characters, of approved size and style, at an approved location in the face of the element (e.g. abutment, pier, etc.) as directed by the ENGINEER.
- P. Curing Concrete:** All concrete, other than concrete below ground surface and not in forms, and except as elsewhere specified, shall be cured by keeping all surfaces continuously wet for a period of at least seven (7) days after pouring by frequent and thorough sprinkling of the concrete and forms. If the forms are removed within seven (7) days, the concrete shall be cured by providing approved protection from the sun with suitable canvas or burlap, or other satisfactory covering and keeping such covering and the concrete wet for the period specified. Whenever placing of concrete is discontinued, the concrete already placed shall be kept continuously wet by adequate sprinkling of the concrete and forms until concreting is resumed. Such sprinkling of the concrete, forms and coverings shall be adequate to keep the parts thoroughly soaked with water. During the curing, no parts of forms, concrete or coverings shall be permitted to become dry. The use of curing water, burlap, canvas, or other materials which discolor the concrete will not be permitted.
- Q. Surface Repairs:** Immediately following the removal of forms, all fins and irregular projections shall be removed from all exposed surfaces. All metal devices used to tie the forms together and hold them in correct alignment and location shall be removed in such a manner that no metal shall remain within one inch of the surface of the concrete. The method of removal of such ties shall not cause injury to the surface of the concrete. The cavities produced by form ties, and all other holes, honeycomb spots, broken edges or corners, and other defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with mortar consisting of cement and fine aggregate mixed in the proportions used in the concrete. The mortar used in the pointing shall be not more than one hour old. Surfaces which have been restored in this manner shall be kept moist for a period of 24 hours. A rubbed surface finish will not be required for formed surfaces, provided the concrete has a finished appearance free from honeycomb and surface irregularities. In case any part of the exposed surface is honeycombed, the area affected, and as much more of the exposed surface as will be required to provide satisfactory finish appearance, must then be given a rubbed surface finish so that the rubbed area blends into the adjacent surface. The amount and extent of rubbing required will depend on the character of surface produced by the forms. In no case shall a cement paint or plaster be applied to the surface of the finished concrete.
- R. Defective:** The operation of depositing and compacting the concrete shall, in general, be conducted so as to form dense, impervious concrete of uniform texture which shall show smooth faces on exposed surfaces. If any section of concrete is found to be defective, it shall be removed or repaired by the Contractor, as directed by the ENGINEER.

4.7 FABRICATION OF PRECAST/PRESTRESSED ELEMENTS

A. General:

1. Prestressing steel shall conform to Section 070120 and prestressing forces shall be in accordance with the project plans;
2. Embedded Steel Plates and Angles, Steel Connectors: Embedded steel plates and angles, and fabricated steel connector assemblies shall conform to the structural steel requirements of Section 070125 of the CSX Design and Construction Standard Specifications. The embedded plates and angles shall be placed at the dimensions shown or specified on the plans, with a tolerance of $\pm \frac{1}{8}$ inch along the edge or surface placed; when plate or angle surfaces are shown to be flush, the tolerance shall be $+ 0$ inch out from the surrounding surface, $-1/16$ inch in from the surrounding surface;
3. Logo and Date: The CONTRACTOR shall cast the CSX logo and the year of construction in characters of approved size and style, at an approved location in the face of substructure elements (e.g. abutment, pier, etc.) as directed by the ENGINEER.

4. Concrete Curing: Concrete shall be protected as required by AREMA recommendation, for a minimum of 7 days. The preferred method of curing normal weight concrete is a wet cure by continuous sprinkling, application of mats or fabric kept continuously wet, or a polyethylene film .004 inch minimum thickness. When polyethylene film is used for curing, all adjoining edges shall be lapped 4 inch and sealed with waterproof tape. Membrane curing compounds are permitted on precast concrete surfaces, except those that will abut other new concrete. Curing of such abutting surfaces shall be by wet curing methods only. Membrane curing compounds shall be compatible with the Water Repellent per Section 070525 of the CSX Design and Construction Standard Specifications, or the membrane curing compound shall be removed to promote penetration and adhesion of the Water Repellent to the concrete.

B. Superstructure Units:

1. Concrete minimum compressive strength of prestressed box beams/girders shall be 8500 PSI, unless indicated otherwise on the plans. Where lightweight concrete is used, the fresh density of the lightweight concrete shall be no more than 115 pcf as determined in accordance with ASTM C138;
2. Formwork: The formwork for precast superstructure elements shall be constructed according to the project plans. The following tolerances are acceptable for the finished element:
 - a. Length: +0 inch, - ¼ inch.
 - b. Width (overall): $\pm 1/4$ inch.
 - c. Depth (overall): $\pm 1/4$ inch.
 - d. Thickness: $\pm 1/8$ inch.
 - e. Flatness of surfaces: $\pm 1/8$ inch.
 - f. Flatness of mating surfaces or bearing surfaces: +0 inch; -1/16 inch.
 - g. Camber Deviation: $\pm 1/8$ inch per 10 feet.
 - h. Position of Prestressing Tendons: $\pm 1/4$ inch.
 - i. Position of stirrup bars: ± 1 inch.

Note: Additional tolerances may be found in the project plans. Tolerances beyond those listed, unless otherwise stated in the project plans, shall be submitted to the ENGINEER for review

3. Concrete curbs (if integral to the boxes/girders) shall be cast no sooner than 3 days after the prestressing tendons in box beams have been released and the prestress force transferred to the concrete.

C. Substructure Units:

1. Minimum compressive strength of concrete caps, wingwalls and backwalls shall be 5000 PSI at 7 days, unless indicated otherwise on the plans. Concrete shall be air entrained. Where lightweight concrete is used, the fresh density of the lightweight concrete shall be no more than 115 pcf as determined in accordance with ASTM C138;
2. Formwork: The formwork for precast substructure elements shall be constructed to provide the following tolerances to the finished element:
 - a. Length and width: $\pm 1/8$ inch.
 - b. Thickness: $\pm 1/8$ inch.
 - c. Flatness of surfaces: $\pm 1/8$ inch.
 - d. Flatness of mating surfaces or bearing surfaces: +0 inch; -1/16 in.

D. Concrete Piling:

1. Piles shall be cast monolithically in a horizontal position on slabs of such strength and rigidity that the longitudinal axes of the members shall be truly straight from end to end. Anchorages shall be of such construction as to preclude any appreciable movement under stressing operations.

4.8 COLD WEATHER CONCRETE PLACEMENT

- A. General:** When the atmosphere temperature is 40° F or lower, or is forecast to drop below that temperature within 24 hours of the time concrete is to be placed, special methods shall be used in producing, placing and protecting the

concrete. The exact methods of placing, producing, protecting and curing concrete to be followed during all such cold weather work shall be specifically approved by the ENGINEER for each type of construction before concreting will be permitted to start. Notwithstanding such approval by the ENGINEER, the CONTRACTOR shall assume all risks connected with placing concrete under cold weather conditions. Should the concrete prove unsatisfactory; it will be rejected and shall be removed and replaced with satisfactory concrete. No allowance shall be made for removing and replacing defective concrete. In general, and unless otherwise directed by the ENGINEER, the methods of producing, placing and protecting concrete in cold weather shall meet the requirements of Section 4.4 B through D following. Also, refer to ACI 306.

- B. Production: Adequate equipment for heating the concrete materials shall be provided. No ingredient that is frozen or contains ice shall be placed in the mixer. Concrete ingredients shall be heated to produce concrete having a temperature at time of delivery of not less than 50° F nor greater than 70° F. A temperature of 60° F is preferred. Heating shall be accomplished by heating either the aggregates or the mixing water, or both. When the water temperature is above 165° F, the aggregate shall be premixed with the water for at least one (1) minute before cement is added. Cement shall not be mixed with water or aggregates having a temperature above 165° F.
- C. Placing and Finishing: Concrete shall not come in contact with forms and equipment containing ice or snow. If required by the ENGINEER, the formed area shall be covered and an air temperature of 50° F maintained for 24 hours on all surfaces against which the concrete is to be placed. During placing and finishing, the temperature of concrete shall be maintained between 50° F and 70° F.
- D. Protection: When freezing temperatures are forecast, facilities meeting the approval of the ENGINEER shall be provided, prior to beginning concrete placement, capable of maintaining the ambient air temperature at the surface of the concrete or forms at not less than 50° F for five (5) days or 70° F for three (3) days. Protective measures shall be maintained for at least four (4) days beyond the period specified above. During this period, the concrete temperature shall not be allowed to drop below 40° F. Sudden cooling (in excess of 20° F temperature change in any 24-hour period) of ambient air temperature at the surface of the concrete or forms will not be permitted.

4.9 HOT WEATHER CONCRETE PLACEMENT

- A. General: When the atmospheric temperature is 90° F or higher, or is forecast to rise above that temperature within 24 hours of the time concrete is to be placed, special methods shall be used in producing, placing and protecting the concrete. The exact methods of placing, producing, protecting and curing concrete to be followed during all such hot weather work shall be specifically approved by the ENGINEER for each type of construction before concreting will be permitted to start. Notwithstanding such approval by the ENGINEER, the CONTRACTOR shall assume all risks connected with placing concrete under hot weather conditions. Should the concrete prove unsatisfactory; it will be rejected and shall be removed and replaced with satisfactory concrete. No allowance shall be made for removing and replacing defective concrete. In general, and unless otherwise directed by the ENGINEER, the methods of producing, placing and protecting concrete in hot weather shall meet the requirements of Section 4.5 B through D following. Also, refer to ACI 305.
- B. Production: Stockpiled aggregates shall be saturated and the surface shall be kept moist by intermittent sprinkling or continuous fog spray. Mixing water shall be kept cool by adequate protection of storage tanks and piping. Supply lines shall be shaded, insulated or buried. When necessary to produce and maintain concrete at an acceptable temperature, chopped or crushed ice shall be added directly into the mixer, up to the limit of 50% by weight of the total water required. Ice shall be added at a rate and in a manner that it will be completely melted during the mixing period. Chilled mixing water will be acceptable in lieu of chopped or crushed ice. Retarding admixtures may be used when and as approved by the ENGINEER.
- C. Placing and Finishing: The temperature of concrete when placed shall not exceed 75° F. Forms and reinforcing shall be wet-down immediately before concrete is placed. Wetting down of areas around the work to cool the air and increase humidity is recommended.
- D. Protection: If, in the opinion of the ENGINEER, proper protection is not being provided, the ENGINEER may order concrete operations to be suspended until adequate protective measures are provided. Concrete shall be kept cool and moist during the specified curing period. When air temperature exceeds 90° F and soon as practicable, without damage to the surface finish, all exposed concrete shall be kept continuously moist by means of fog sprays, wet burlap, cotton mats or other effective means.

PART 5 – MEASUREMENT AND PAYMENT

NOT USED.

END OF SECTION 070105



PART 1 – GENERAL

1.1 DESCRIPTION

- A. This Section covers material specifications for GROUT used on CSX Transportation bridge construction projects.

1.2 ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
AREMA	American Railway Engineering and Maintenance of Way Association
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials International
DOT	Department of Transportation

PART 2 - MATERIAL

2.1 CEMENTITIOUS GROUT

- A. Cementitious grout is a single component compound of hydraulic cement and fine aggregate which is flowable and pumpable. Cementitious grout shall comply with ASTM C1107 and shall be non-shrink, non-metallic type, and shall provide a minimum 7 day compressive strength of 4,000 psi when tested in accordance with ASTM C109.
- B. Where small quantities of cementitious grout are required to fill soil voids or other non-structural uses, such grout may be made by mixing 1 part Portland cement and 3 parts clean sand thoroughly, and then adding potable water to form a suitable consistency for the work. The Portland cement and sand (fine aggregate) shall comply with Section 070105 of these CSX Design and Construction Standard Specifications.

2.2 EPOXY GROUT

- A. Epoxy grout is a multi-component compound of high-strength epoxy and fine aggregate. Working time is limited by the epoxy, follow the manufacturer's recommendations for the specific epoxy grout used.
- B. Epoxy grout shall provide a minimum of 10,000 psi compressive strength, when tested in accordance with ASTM C579, Method B and shrinkage less than 0.05 percent when tested in accordance with ASTM C531.

2.3 HANDLING AND STORING MATERIALS

- A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Store grout materials in unopened packaging from manufacturer in a clean dry area protected from sunlight. Do not allow grout materials to freeze. Epoxy grout materials should be stored at temperatures as specified by the manufacturer.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Certified copies of the manufacturer's test results, performed as required by the ASTM specifications for each type of material, shall be furnished to the ENGINEER.
- B. Additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records, each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER. For additional information regarding each submittal refer to the appropriate section of this specification.

PART 4 - EXECUTION

NOT USED.

PART 5 – MEASUREMENT AND PAYMENT

NOT USED.

END OF SECTION 070110



PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section covers material specifications for reinforcing steel bars, welded wire fabric, and prestressing steel used on CSX Transportation bridge construction projects.

1.2 ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

AASHTO	American Association of State Highway and Transportation Officials
ANSI.....	American National Standards Institute
AREMA	American Railway Engineering and Maintenance of Way Association
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials International
CRSI.....	Concrete Reinforcing Steel Institute
DOT	Department of Transportation
PCI	Precast/Prestressed Concrete Institute
PTI	Post-Tensioning Institute
WRI.....	Wire Reinforcement Institute
WWR	Welded Wire Reinforcement
BUILDER	Either CSXT company forces or the CONTRACTOR
CONTRACTOR.....	The business entity contracted by CSXT for construction of the project
ENGINEER.....	The Assistant Chief Engineer – Structures, CSXT or designated representative
RAILROAD.....	CSX Transportation (CSXT)

1.3 DISCLAIMER

- A. Approval by the ENGINEER is only for the purpose of confirming compliance with the contract plans and specifications. Approval shall not relieve the CONTRACTOR from responsibility for correctness, quantity and quality, nor for completeness of Work in accordance with the plans and specifications.

PART 2 - MATERIAL

2.1 REINFORCING STEEL

- A. Reinforcing steel bars shall be deformed bars of new billet steel conforming to the requirements of ASTM A615, Grade 60 or ASTM A706, Grade 60. Galvanized reinforcing steel bars shall conform to the requirements of ASTM A1094.

2.2 WELDED WIRE REINFORCEMENT

- A. Welded wire reinforcement (WWR) is a prefabricated reinforcement consisting of parallel series of cold drawn or cold rolled plain or deformed wire welded together in square or rectangular grids. WWR shall conform to the requirements of ASTM A1064 Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

2.3 PRESTRESSING STEEL STRAND AND BARS

- A. Prestressing strand shall conform to the requirements of ASTM A416, Grade 270 – Seven-Wire Uncoated Low Relaxation Strand. Prestressing strand or wire shall not be spliced. High-strength steel bars for prestressed concrete or for post-tensioning prestressed concrete shall conform to the requirements of ASTM A722.

2.4 TIE WIRE AND BAR SUPPORTS

- A. The reinforcing steel bars shall be connected using wire ties conforming to ASTM A510. Tied connections shall be made in accordance with CRSI Manual of Standard Practice and the CRSI publication "Reinforcing Bar Placing".
- B. Supports for reinforcing steel bars and welded wire fabric shall conform to the requirements of ANSI/CRSI RB4.1, Supports for Reinforcement Used in Concrete.

2.5 HANDLING AND STORING MATERIALS

- A. Reinforcing steel bars and WWR shall be stored in racks in such a manner as to avoid contact with the ground. If reinforcement is to remain on the site for more than one month, it shall be covered to protect it from weather. If reinforcement accumulates heavy rust, dirt, mud, loose scale, paint, oil, or any other foreign substance during storage, it shall be cleaned before being used. Severe deterioration of this kind may be a basis for rejection.
- B. All reinforcement shall be protected as far as practicable from mechanical injury or surface deterioration from rusting or other cause. Before placement of the surrounding concrete, the reinforcement shall be free from dirt, scaly rust, loose mill scale, paint, oil, grease, and other foreign substances.
- C. Prestressing steel shall be stored in such a manner as to protect it from moisture or other corrosive environment, and from foreign matter, at all times.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. Submittals: The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for reinforcing, prestressing and post-tensioning steel materials, additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records, each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER. For additional information regarding each submittal refer to the appropriate section of this specification.
 - 1. Detail drawings
 - 2. Mill test reports

PART 4 - EXECUTION

4.1 TESTING

- A. Certified copies of the manufacturer's test results, performed as required by the ASTM specifications for each type of material, shall be furnished the ENGINEER.

4.2 REINFORCING STEEL PLACEMENT FOR CAST-IN-PLACE CONCRETE

- A. CONTRACTOR shall, before proceeding with the work, field check all dimensions, and submit for review a complete set of any necessary shop drawings. No work shall be done until the shop drawing review is completed. In case of correction or rejection, the contractor shall revise and resubmit the drawings until they are acceptable to the engineer and such procedure will not be considered as a cause for delay.
- B. Fabrication: Reinforcing bars shall be detailed and fabricated in accordance with AREMA recommendations.
- C. Splicing: Reinforcing bars shall be cut to the lengths indicated on the Plans or longer as approved by the ENGINEER. Splices which are permitted, unless otherwise shown on the Plans, shall be designed in accordance with applicable AREMA recommendations. Where practicable, the locations of the laps shall be staggered so the neighboring bars will not have adjacent laps.
- D. Placing: Reinforcement shall be placed accurately in the position indicated on the Plans and shall be firmly held in place during the deposition and vibration of the concrete. This shall be accomplished by fastening the bars at all intersections and splices by wires or approved clips, by the use of bars or other suitable spacers, or as otherwise approved by the ENGINEER. Suitable supports of approved number and character shall be used to support and retain

the reinforcement in the locations required and at proper distances from the forms. If such supports are to be left in place in the concrete, they shall be of metal and all parts of such metal supports extending to within one inch of what will be an exposed concrete surface shall be galvanized.

- E. Grouting: Reinforcing bars grouted into existing concrete and / or masonry as shown on the Plans will be grouted using a 2-compound epoxy mixed with suitable mineral filler. The mineral filler shall be as recommended by the epoxy manufacturer. The method of mixing and application shall be as recommended by the manufacturer.

4.2 PRESTRESSING STEEL AND REINFORCING STEEL PLACEMENT FOR PRECAST CONCRETE

- A. Prior to stressing, the CONTRACTOR shall submit to the inspector representing the RAILROAD for his approval the detailed computations of proposed gauge pressures and elongations.
- B. The location of the center of gravity of the prestressing steel shall be as indicated on the drawings. Unless tolerances for location of steel are shown, a maximum variation of $\pm \frac{3}{16}$ inch will be permitted. All wires or strands shall be cleaned to the satisfaction of the inspector representing the RAILROAD and shall be in position before the stressing operation is begun.
- C. If wires or strands are stressed individually, the pretensioning force, as measured by the approved elongation, shall be equally applied to the individual wires or strands until the required stress is reached.
- D. If wires or strands are stressed as a group, they shall be placed in their proper position in the forms and stressed individually with an initial force equal to 10 percent of tensioning load, but not less than 500 pounds. In any group of wires or strands, the initial load shall not vary by more than 5 percent.
- E. The maximum applied stress shall not exceed 175,000 psi.
- F. Strands shall not be spliced.
- G. The mild steel reinforcing shall not be placed in final position until after the prestressing operation is complete.
- H. The pretensioning force shall be determined by measuring elongation on permanently installed gauges and by checking jack pressures. The difference between the stresses thus determined shall not exceed 5 percent. The pressure gauge on the jack shall be calibrated to the inspector's satisfaction to indicate a pressure in the jack within two percent at the pressure corresponding to full prestress tension in the wires or strands.
- I. Permanent records shall be made of elongation and pressure readings during stressing operations. The original records shall be presented to the inspector for transmittal to the RAILROAD.
- J. The force in the prestressing steel shall be transferred to the concrete smoothly, gradually, and equally from all wires or strands. Release from the anchorage by cutting or burning is strictly prohibited. Between bulkheads, and after the force in the steel is transferred to the concrete, wires or strands may be either cut or burned off symmetrically about the horizontal and vertical axes of the members. Any blocking between bulkheads, which may restrain horizontal movement of the member, shall be removed prior to transfer of stress.
- K. Stress shall not be released until the concrete has attained strength of 4000 psi for substructure elements or 5500 psi for superstructure elements, unless indicated otherwise on the plans.

PART 5 – MEASUREMENT AND PAYMENT

NOT USED.

END OF SECTION 070120

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PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section covers falsework used in construction to support spanning or arched structures in order to hold the component in place until its construction is sufficiently advanced to support itself. It includes falsework designed to hold and support fresh concrete, or to stabilize girders during stages of erection, as well as temporary spans used to support track and carry live load and other applied loads over other portions of the construction. Other temporary structures include temporary work platforms spanning waterways or wetlands adjacent to the permanent construction.
- B. General conditions for this work are in accordance with Division 1 of the CSX Design and Construction Standard Specifications.

PART 2 - MATERIAL

2.1 GENERAL

- A. All materials shall be new materials meeting the requirements of Division 7, 100 Series of the CSX Design and Construction Standard Specifications shown below:
 - Concrete070105
 - Reinforcing.....070120
 - Steel.....070125
 - Timber070130
- B. Any used material proposed shall be in good condition, free of section loss, or other defects and approved by the ENGINEER.

2.2 HANDLING AND STORING MATERIALS

- A. CONTRACTOR shall handle and store materials only in approved areas.

2.3 DISPOSAL

- A. All Falsework material shall be removed and disposed of by the CONTRACTOR upon completion of the project, including material furnished by the RAILROAD. When specified, steel falsework spans including ties and guard rails, shall be retained by the RAILROAD.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER.
 1. Detailed plans and calculations signed and sealed by a licensed Professional Engineer in the Commonwealth, District, State or Province where the TEMPORARY STRUCTURE / FALSEWORK is being constructed.
 2. Detailed plans showing storage area, if necessary
 3. Support pilings, if necessary
 4. Erection diagram

5. Steel or timber material grades and stresses, use of used material must be approved by the ENGINEER prior to erection
 6. For modular systems, the method of vertical and horizontal adjustments
- B.** CONTRACTOR shall furnish one (1) complete electronic copy of detailed shop drawings for approval by the ENGINEER prior to starting fabrication. By submitting shop drawings, the CONTRACTOR thereby represents that all field measurements, field construction criteria, materials, catalog numbers and similar data have been determined and verified, and that the shop drawings have been checked and coordinated with the requirements of the work and of the contract documents. After approval of shop drawings, the CONTRACTOR shall supply the ENGINEER with one (1) complete electronic set of approved reproducible drawings.

PART 4 - EXECUTION

4.1 INSTALLATION

- A.** Temporary spans shall be anchored to prevent lateral or longitudinal movement.
- B.** The ground shall be adequately prepared and steps taken to prevent erosion and settlement.
- C.** Suitable foundation pads or other bases shall be provided by CONTRACTOR and shall be properly leveled.
- D.** Any foundation pads and load-distributing members laid on a slope shall be adequately prevented from movement.
- E.** Falsework which cannot be founded on a satisfactory footing shall be supported on piling which shall be spaced, driven and removed in a manner approved by the ENGINEER.
- F.** TEMPORARY STRUCTURES / FALSEWORK shall be properly maintained and inspected as required by the ENGINEER.
- G.** TEMPORARY STRUCTURES / FALSEWORK shall be completely removed by the CONTRACTOR, except for steel Falsework spans, including ties and guard rails, when specified.

PART 5 – MEASUREMENT AND PAYMENT

5.1 MEASUREMENT

- A.** Measurement for payment of TEMPORARY STRUCTURES / FALSEWORK, as shown on the drawings, as specified in this Section and as accepted in the final work, shall be on a LUMP SUM basis as set forth in the Contract Documents.

5.2 PAYMENT

- A.** Payment for TEMPORARY STRUCTURES / FALSEWORK, measured as stated above, will be at the LUMP SUM price per bid set forth in the Contract Documents. Said price shall be full compensation for furnishing all labor, materials, tools, equipment, forms, supplies, inspections, storage area, accessories, supervision, engineering and all other items of expense to TEMPORARY STRUCTURES / FALSEWORK.
- B.** Any portion of the work not listed in the bid form shall be deemed to be incidental to the item of work which it is associated with and shall be included in the cost of the LUMP SUM price bid.
- C.** Where no allowance has been made for TEMPORARY STRUCTURES / FALSEWORK in the prescribed Bid Sheet or CONTRACTOR'S price form this item shall be considered incidental to the work which necessitates it.

END OF SECTION 070205



PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section covers design, construction, maintenance and removal of cofferdams for marine construction and/or for structure excavation, along with other types of braced excavation.
- B. General conditions for this work are in accordance with Division 1 of the CSX Design and Construction Standard Specifications.

PART 2 - MATERIAL

2.1 GENERAL

- A. All materials shall meet the requirements of Division 7, 100 Series of the CSX Design and Construction Standard Specifications shown below:
 - Concrete 070105
 - Reinforcing..... 070120
 - Steel..... 070125
 - Timber..... 070130
- B. Any used material proposed shall be in good condition, free of section loss, or other defects and approved by the ENGINEER.

2.2 HANDLING AND STORING MATERIALS

- A. Materials shall be handled and stored according to manufacturer’s recommendations, in an approved location.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER.
 - 1. Temporary Waterway Diversion Structure, if applicable;
 - 2. Design calculations for the cofferdam and or other braced excavation, and any temporary waterway diversion structure required for the work, signed and sealed by a Professional Engineer licensed in the Commonwealth, District, State or Province where work is to be performed. Shoring for railway Live Load shall be designed to resist a vertical live load surcharge of 1800 lbs. per square foot, in addition to active earth pressure. The surcharge shall be assumed to act on a continuous strip, 8’-6” wide. Lateral pressures due to surcharge shall be computed using the strip load formula shown in the AREMA MRE. Allowable stresses in materials shall be in accordance with AREMA recommendations.
 - 3. Erection drawings and construction procedure detailing the proposed method of cofferdam and/or braced excavation construction and other details not fully shown in the Contract Drawings. Such drawings shall be signed and sealed by a Professional Engineer licensed in the Commonwealth, District, State or Province where work is to be performed, and approved by the ENGINEER before construction is started.

PART 4 - EXECUTION

4.1 INSTALLATION

- A.** Preferred protection is the cofferdam type that completely encloses the excavation. Where dictated by conditions, partial cofferdams with open sides away from the track may be used. Cofferdams shall be constructed using steel sheet piling or steel soldier beams with timber lagging. Wales and struts shall be provided as needed.
- B.** Safety railing meeting the requirements of 29 CFR 1910.23 shall be installed when temporary shoring is within 12 feet of track, or depth is greater than 6 feet.
- C.** A minimum distance of 10 feet from centerline of the track to face of nearest point of shoring shall be maintained.
- D.** Cofferdams shall be constructed to keep the excavations free from earth, water, ice, or snow, and to permit excavations to be carried to the depths indicated on the plans. Additional bracing may be required to satisfactorily perform excavation, dewatering, and other required construction operations. Permanent sheeting system shall be returned to its intended condition after all cofferdam equipment and material, including any additional bracing, has been removed.
- E.** Cofferdams shall be designed, inspected daily, and maintained in compliance with the applicable requirements of 29 CFR 1926.651, 1926.652, and 1926.802.
- F.** Shoring protection shall be provided when excavating adjacent to an active railroad track, except as noted below.

Shoring will not be required if both the following conditions are satisfied:

 - 1. Excavation does not encroach upon a 1 horizontal: 1 vertical theoretical slope line starting at the bottom of the near end of the tie (approximately 4'-3" from centerline of the track).
 - 2. Track is on level ground or in a cut section and on stable soil.
- G.** Dewatering equipment and any additional bracing shall be of adequate quality and capacity and shall be so arranged as to permit their proper functioning in connection with the cofferdam. Dewatering equipment and bracing shall be so located to permit construction of the structure in accordance with the plans.
- H.** All damage caused by the failure of a cofferdam to perform its proper functions shall be the responsibility of the CONTRACTOR. It shall also be the CONTRACTOR's responsibility to protect all stream banks from erosion by reason of restriction of the channel caused by the erection of the cofferdam to limits greater than that shown on the plans for the CONTRACTOR's own convenience. In that situation, bank restoration shall be at the CONTRACTOR's own expense. The ENGINEER shall approve all repair methods proposed by the CONTRACTOR prior to the CONTRACTOR beginning any remedial activities for which they are liable.
- I.** It shall be the CONTRACTOR's responsibility to place the cofferdam so that it will not interfere with any substructure components.
- J.** CONTRACTOR shall provide and maintain COFFERDAM access.
- K.** The CONTRACTOR shall establish and maintain a sediment removal area(s) to retain the discharge for a sufficient period of time using equivalent best management practices as approved by the ENGINEER, in order that any discharge entering the stream will be as clear as the flowing stream.
- L.** The CONTRACTOR shall fully remove cofferdam installation or the waterway diversion structure, including anchor spuds if used, after such time that it is determined by the ENGINEER to be no longer necessary. The removal shall be sequenced to minimize turbidity and the discharge of materials into the waterway. Additional temporary erosion control measures, as determined by the ENGINEER, may need to be employed to facilitate removal.

PART 5 – MEASUREMENT AND PAYMENT

5.1 MEASUREMENT

- A.** Measurement for Payment of COFFERDAM/SHEETING/SHORING - INSTALLATION, MAINTENANCE AND REMOVAL, as shown on the drawings, as specified in this section and as accepted in the final work, shall be on a LUMP SUM basis.

5.2 PAYMENT

- A.** Payment for COFFERDAM/SHEETING/SHORING - INSTALLATION, MAINTENANCE AND REMOVAL, measured as stated above, will be at the contract LUMP SUM price bid. Said price shall be full compensation for furnishing all labor, materials, tools, equipment, forms, supplies, inspections, storage area, accessories, supervision, engineering and all other items of expense necessary for this item of the work.
- B.** Any portion of the work not listed in the bid form shall be deemed to be incidental to the item of work which it is associated with and shall be included in the cost of the unit price for that item shown on the bid form.

END OF SECTION 070210



PART 1 – GENERAL

1.1 DESCRIPTION

- A. This Section covers the preparation, demolition, removal, and disposal of various structures or portions of such structures as shown below:
 - 1. Those structures, or portions of structures, shown in the Plans to be removed, including marine fender systems;
 - 2. Those structures, or portion of structures, which are necessary to be removed in order to construct new structures, as approved by the ENGINEER;
 - 3. Appurtenances or obstructions designated in the Contract Documents to be included in this item of payment for the work.
- B. The work shall include furnishing, erecting, and removal of falsework and special lifting devices, as required to complete the work.
- C. General conditions for this work are in accordance with Division 1 of the CSX Design and Construction Standard Specifications.

PART 2 - MATERIAL

NOT USED.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. The CONTRACTOR shall prepare and deliver technical submittals, signed and sealed by a Professional Engineer licensed in the Commonwealth, District, State, or Province where the work is performed, for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER.
 - 1. For all demolition methods, the CONTRACTOR shall submit for review and approval of the ENGINEER, a demolition plan that describes the method of removal and equipment to be used. If a portion of the existing structure is to remain and be connected to the proposed new structure, types of rebar splices or couplers, and method of straightening or cutting rebar shall be included in the plan.
 - 2. Lead safety plan
 - 3. Existing/adjacent structures monitoring plan
 - 4. Disposal plan, including certifications of disposal sites, for all materials to be removed. The disposal of all portions of structure in accordance with these specifications and the details shown on the contract documents, shall satisfy the requirements of all Federal, State/Provincial and local regulations.
 - 5. For protective shield systems, the CONTRACTOR shall submit working drawings and calculations. The drawings shall provide full details, dimensions, and types of materials proposed for use. The protective shield systems shall not be installed until authorization to proceed is given by the ENGINEER. Upon completion of the work or when directed by the ENGINEER, the protective shield system shall be removed. Any encumbrances to existing railway clearance due to the protective shielding system shall be specifically denoted in the submittals.

- B. The CONTRACTOR shall furnish one (1) complete electronic copy of detailed shop drawings for approval prior to starting fabrication. By approving and submitting shop drawings, the CONTRACTOR thereby represents that all field measurements, field construction criteria, materials, catalog numbers and similar data have been determined and verified, and that the shop drawings have been checked and coordinated with the requirements of the work and of the contract documents. After approval of shop drawings, the CONTRACTOR shall supply the RAILROAD with one (1) complete electronic set of reproducible approved drawings.

PART 4 - EXECUTION

4.1 EXECUTION

- A. Remove and dispose of existing bridge components or appurtenances when required to effect placement of new bridge elements and as detailed in the Project Plans. All material removed by the CONTRACTOR, unless specified otherwise on the Project Plans, shall be the property of and be entirely removed from the RAILROAD's property by the CONTRACTOR. Any salvage value of such materials shall be reflected in the bidder's proposal.
- B. Remove the structures in such a way so as to leave no obstructions to any proposed new structures or to any waterways. Pilings shall be pulled, cut off, or broken off in accordance with the requirements of the construction permit or other Contract Documents, or if not specified, as indicated below:
1. Any pilings, fender system or portion thereof, to be removed shall require the removal of all components to a minimum one (1) foot below the existing mud/ground line, or finish ground line, whichever is lower;
 2. Any pilings, fender system or portion thereof, to be removed within a navigable channel shall be removed to a minimum one (1) foot below the proposed dredge line.
- C. Inadvertent or intentional dumping, or placement of timber or any material to be removed, into a waterway or flood plain is not permitted.
- D. For superstructure or other material to be salvaged for reuse by the RAILROAD, the following conditions apply:
1. When a superstructure is specified to be salvaged for re-erection, all members and loose parts shall be properly match-marked, all machined steel surfaces treated with an approved anti-rust compound, and all loose parts wired to adjacent members or packed in marked boxes;
 2. Materials that are to be salvaged under the contract and which the ENGINEER deems fit for reuse shall be carefully removed in transportable sections and stockpiled near the site at a location designated by the ENGINEER. If the material for reuse is unfit, through no fault of the CONTRACTOR, the material shall be disposed of accordingly. When the CONTRACTOR damages or destroys such material, the CONTRACTOR shall repair or replace the material in a manner satisfactory to the ENGINEER.
- E. When partially removing structural steel, the CONTRACTOR will not nick, gouge, or damage in any way steel material to remain. Any damaged, nicked, gouged, etc. material shall be repaired or replaced at the CONTRACTOR's expense to the satisfaction of the ENGINEER.
- F. Rivet removal shall be done by mechanical means, at no time are rivets to be removed by burning, flame cutting, or similar type methods unless approved by the ENGINEER or authorized representative.
- G. The CONTRACTOR is hereby warned that the paint coating on the existing structure MAY contain lead. Accordingly, the CONTRACTOR shall comply with the following regulations:
1. OSHA Regulation "Lead Exposure in Construction" 29 CFR 1926.62;
 2. EPA "Resource Conservation and Recovery Act of 1976" 40 CFR 240 through 273;
 3. Clean Air Act, 40 CFR, Sub-Chapter C, Parts 50 through 99;
 4. Clean Water Act, 40 CFR, Sub-Chapter D, Parts 100 through 149.
- H. Prior to beginning any cutting, grinding, or welding on the existing steel structure, the CONTRACTOR shall submit a lead safety plan in accordance with OSHA 29 CFR 1926.62, detailing their requirements for use of respirators, containment areas, handling of contaminated garments, and testing of employees.

- I. At a minimum, vacuum power tool clean any coated steel member to bare metal as defined by SSPC-SP11 at a minimum of 4 inches either side of any area to be heated (torch cutting, sawing, grinding, etc.) in accordance with 29 CFR 1926.354. Provide air supplied respirators in accordance with 29 CFR 1926.62 and 29 CFR 1910.134.
- J. For concrete elements on concrete bridges to be partially removed and widened, remove concrete by manually or mechanically operated pavement breakers, by concrete saws, by chipping hammers, or by hydro-demolition methods. Do not use explosives. Where concrete is to be removed to neat lines, use concrete saws or hydro-demolition methods capable of providing a reasonably uniform cleavage face. If the equipment used will not provide a uniform cut without surface spalling, first score the outlines of the work with small trenches or grooves.
- K. The CONTRACTOR shall comply with all regulations, as they apply to this project.

PART 5 – MEASUREMENT AND PAYMENT

5.1 MEASUREMENT

- A. Measurement for payment to DEMOLISH AND REMOVE EXISTING STRUCTURE as shown, or which is necessary to be removed in order to construct new structures, shown on the drawings, as specified in this Section and as accepted in the final work, shall be on a LUMP SUM basis.

5.2 PAYMENT

- A. Payment for DEMOLISH AND REMOVE EXISTING STRUCTURE, measured as stated above, will be at the contract unit price LUMP SUM bid. Said price shall be full compensation for furnishing all labor, materials, tools, equipment, materials and all other items of expense to DEMOLISH AND REMOVE EXISTING STRUCTURE.
- B. Any portion of the work not listed in the bid form shall be deemed to be incidental to the item of work which it is associated with and shall be included in the LUMP SUM bid.
- C. Where no allowance has been made for DEMOLISH AND REMOVE EXISTING STRUCTURE in the prescribed Bid Sheet or CONTRACTOR'S price form this item shall be considered incidental to the work which necessitates it.

END OF SECTION 070220



PART 1 – GENERAL

1.1 DESCRIPTION

- A. This Section covers requirements, and measurement and payment for work necessary to backfill excavation with, or otherwise place, flowable fill.
- B. General conditions for this work are in accordance with Division 1 of the CSX Design and Construction Standard Specifications.

PART 2 - MATERIAL

2.1 GENERAL

- A. Cement, aggregate, water and admixtures shall meet the requirements of Division 7, 100 Series of the CSX Design and Construction Standard Specifications shown below.

Concrete070105

- 1. For fine aggregates, any clean fine aggregate with 100% passing a $\frac{3}{8}$ inch mesh sieve and not more than 15% passing a No. 200 sieve may be used for flowable fill, other gradation requirements are waived.
- 2. High air generators or foaming agents may be used in lieu of conventional air entraining admixtures and shall be added at the jobsite and mixed in accordance with the manufacturer's recommendations.
- B. Pozzolan shall be fly ash, silica fume or slag meeting the following requirements:
 - 1. Fly ash shall meet the requirements of ASTM C618 (Class C or Class F). Sampling and testing of fly ash shall follow the requirements of ASTM C311.
 - 2. Silica fume shall meet the requirements of ASTM C1240 using the referenced test methods and frequencies.
 - 3. Slag shall meet the requirements of ASTM C989, only ground granulated blast-furnace slag Grade 100 or 120 will be permitted.
 - 4. Fly ash and slag shall not be used in conjunction with Type IP or Type IS cements.
- C. Preformed Foam to be used for cellular concrete flowable fill shall meet the requirements of ASTM C869.

2.2 HANDLING AND STORING MATERIALS

- A. Material shall be handled and stored per manufacturer's recommendations.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. Submittals: The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER.
 - 1. Material specifications for admixtures used.
 - 2. Aggregates: Aggregates shall be sourced from a supplier currently approved by the DOT of the State in which the project is located. The CONTRACTOR shall submit documentation for approval by the ENGINEER indicating such approval.

3. Mix Design – Flowable fill is a low strength concrete containing a low cementitious content for reduced strength development. Cellular concrete flowable fill is a low density concrete containing preformed foam to form a hardened closed cell foam material. The following are suggested mix guides for excavatable, non-excavatable and cellular concrete flowable fill:

	Excavatable	Non-Excavatable	Cellular Concrete
Cement	75-100 LB/CY	75-150 LB/CY	Min 150 LB/CY
Pozzolans	None	150-600 LB/CY	Optional
Water	*	*	*
Air**	5-35%	5-15%	****
28 Day Compressive Strength	Maximum 100 psi	Minimum 125 psi	Minimum 80 psi
Unit weight	90-110 LB/CF	100-125 LB/CF	20-80 LB/CF
Fine Aggregate	***	***	Optional

*Mix designs shall produce a consistency resulting in a flowable self-leveling product at time of placement

**Requirements for percent air, compressive strength and unit weight are for lab designs only and are not intended for jobsite acceptance requirements.

***Fine Aggregate shall be proportioned to yield 1 CY.

****In cellular concrete, preformed foam shall be proportioned at the job site to yield 1 CY in accordance with the Project requirements.

PART 4 - EXECUTION

4.1 INSTALLATION

- A. Delivery: Deliver flowable fill using concrete construction equipment.
- B. Placing flowable fill: Place flowable fill by chute, pumping or other method approved by the ENGINEER. Use the tremie method when placing flowable fill below water. Protect flowable fill from freezing for a period of 36 hours after placement.
 1. Use straps, soil anchors, or other approved means of restraint to ensure correct alignment when flowable fill is used as backfill for pipe or where flotation or misalignment may occur.
 2. Place flowable fill to the designated fill line without vibration or other means of compaction.
 3. Do not place flowable fill during inclement weather, e.g. rain or ambient temperatures below 40° F.
 4. Take all necessary precautions to prevent any damages caused by the hydraulic pressure of the flowable fill during placement prior to hardening.
 5. Provide the means to confine the flowable fill to within the designated space.
 6. Leave the fill undisturbed until the material obtains sufficient strength. Sufficient strength is 35 psi penetration resistance as measured using a hand held penetrometer in accordance with ASTM C403. Provide a hand held penetrometer to measure the penetration resistance of the hardened flowable fill.
- C. Acceptance:
 1. Acceptance will be based on the following documentation and a minimum temperature of flowable fill at the point of delivery of 50° F. For each load of flowable fill delivered to the worksite, furnish a delivery ticket to the ENGINEER containing the following information:
 - a. Project designation, including prefix and milepost
 - b. Date
 - c. Time
 - d. Class and quantity of flowable fill
 - e. Actual batch proportions
 - f. Free moisture content of aggregates
 - g. Quantity of water withheld

PART 5 – MEASUREMENT AND PAYMENT

5.1 MEASUREMENT

- A. Measurement for payment, FLOWABLE FILL, as shown on the drawings, as specified in this Section and as accepted in the final work, shall be on a per CUBIC YARD basis. No measurement or payment will be made for material placed outside the neat line limits or outside the adjusted limits, or for unused or wasted material.

5.2 PAYMENT

- A. Payment for FLOWABLE FILL, measured as stated above, will be at the contract unit price per CUBIC YARD bid. Said unit price shall be full compensation for furnishing all labor, materials, tools, equipment, forms, supplies, accessories, supervision, engineering and all other items of expense to place FLOWABLE FILL to the neat line limits shown on the plans.

END OF SECTION 070265

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PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section covers design, construction requirements, and measurement and payment for retaining walls used on CSX Transportation construction projects. The following types of retaining walls are covered by this specification:
1. Timber walls
 2. Sheet pile walls
 3. Soldier pile and lagging walls
 4. Crib wall
 5. Tie-back wall
 6. Reinforced concrete cantilevered walls
- B. General conditions for this work are in accordance with Division 1 of the CSX Design and Construction Standard Specifications.

PART 2 - MATERIAL

2.1 GENERAL

- A. All materials shall meet the requirements of Division 7, 100 Series of the CSX Design and Construction Standard Specifications shown below:
- | | |
|------------------|--------|
| Concrete | 070105 |
| Reinforcing..... | 070120 |
| Steel..... | 070125 |
| Timber | 070130 |

2.2 HANDLING AND STORING MATERIALS

- A. CONTRACTOR shall handle and store materials only in approved areas.

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work.
1. Design and calculations, signed and sealed by a Professional Engineer licensed in the Commonwealth, District, State or Province where the PROJECT will be constructed. Design calculations for temporary retaining walls required for construction will be submitted to the ENGINEER for approval prior to construction. Design shall meet all applicable CSX Design and Construction Standard Specifications and safety guidelines and AREMA recommendations. Where conflicting design guidelines exist, the CSX Design and Construction Standard Specifications shall govern.
 2. Plans including detail drawings and construction sequence plan
 3. Corrosion Protection details
 4. Mill test reports, Material Certifications for all components

5. Material installation requirements
6. Material storing plan
7. Schedule

PART 4 - EXECUTION

4.1 TIMBER RETAINING WALLS

- A. Construction shall meet all applicable CSX Transportation Specifications and safety guidelines and AREMA recommendations.
- B. Scheduling: Construction schedule shall ensure the minimal disruption to RAILROAD traffic.

4.2 SHEET PILE WALLS

- A. General.
 1. Earthwork: The CONTRACTOR shall not begin steel sheet piling installation until the earthwork in the area where the piles are to be driven has been completed to the extent that the grade elevation is at no more than twelve (12) inches above or below the top of the piling elevations as indicated on the plans;
 2. Site Preparation: Any fill along the alignment of the steel sheet piling must be in place to sub-grade elevations and compacted prior to driving the steel sheet piling. Fill material (except riprap, boulders, bedding and grout) is not to be placed around the steel sheet piling until after the steel sheet piling is in place. All clearing within the area to be occupied by the steel sheet piling shall be completed before the piling is installed;
 3. Utilities: The CONTRACTOR shall ascertain the location of any utilities that pass through the area in which the steel sheet piling is to be driven, and shall protect same during installation and removal (if necessary) of steel sheet piling;
 4. Jetting: Jetting of piling will not be permitted unless approved by the ENGINEER.
- B. Installation.
 1. General: All welding or gas cutting shall be in accordance with the current standards of the American Welding Society.
 2. Interlocks: If any steel sheet piling is damaged in driving or vibrating which has broken interlocks between sections it shall be pulled and replaced at CONTRACTOR's expense.
 3. Virtual Refusal: Steel sheet piling shall be driven to the depths shown on the plans or to virtual refusal. Virtual refusal is defined as ten (10) blows per inch with an approved pile hammer. A pile hammer shall be used to determine virtual refusal. The hammer shall be operating at the manufacturer's recommended stroke and speed when virtual refusal is measured.
 4. Sheet Pile Driving: Steel sheet piling shall be assembled before driving and then driven as a continuous wall, progressively in stages to keep the piles aligned correctly and minimize the danger of breaking the interlock between the sheets. The piles shall be held in proper alignment during driving by means of assembling (frames or other suitable temporary guide structures). Temporary guide structures shall be removed when they have served their purpose.
 5. Vertical Alignment: At any time the forward edge of the steel sheet piling wall is found to be out of correct alignment:
 - a. The piling already assembled and partly driven shall be driven to the required depth.
 - b. Taper piles shall be then driven to bring the forward edge into correct alignment before additional regular piling is assembled and driven. The maximum permissible taper in a single pile shall be ¼" inch per foot of length.
 6. Horizontal Alignment: Steel sheet piling shall be driven to form a relatively straight line between the termini points shown on the plans. Horizontal deviation of any point from a straight line connecting two ends of the wall section shall be a maximum of 2 inches.

7. Lateral Stability: If necessary, CONTRACTOR shall brace and / or provide soil grading as necessary during construction operations in order to provide lateral stability for the steel sheet piling wall.
 8. Vibratory Driver: For steel sheet piling driven into the native soils, pre-drilled soils, or excavated soils a vibratory driver may be used as long as the required depth is obtained.
 9. Sheet Pile Removal: If required, removal of steel sheet piling shall be as noted on the plans or stipulated by the ENGINEER.
 10. Cutting off Sheet Pile: The CONTRACTOR shall cut off the steel sheet piling at the specified elevations. The length of the piling cut off shall be sufficient to permit the removal of all damaged material.
- C. Trench Embedment of Sheet Piling.**
1. General: Steel sheet piling is embedded by excavating a trench and backfilling to the dimensions and lines shown on the drawings;
 2. Backfill Material: Backfill material shall be placed and compacted to the density of the surrounding material, taking care not to displace or damage the steel sheet piling or its protective coating. Backfill material shall contain no frozen soil, sod, brush, roots or other organic material.
- D. Defective Piles and Damaged Coatings.**
1. Defective Piles: Any sheet pile ruptured in the interlock or otherwise damaged during installation shall be pulled and replaced at the CONTRACTOR's expense.
 2. Damaged Coatings: Damaged coating on painted steel sheet piles shall be prepared and repainted in accordance with the manufacturer's specifications of the original coating at the CONTRACTOR's expense. Damaged galvanized coatings shall be repaired in accordance with ASTM A780, Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings, at the CONTRACTOR's expense.

4.3 SOLDIER PILE AND LAGGING WALLS

A. Soldier Pile Installation:

1. Soldier piles shall be driven to the minimum tip elevation indicated in the contract documents.
2. Soldier piles shall be furnished in full-length sections.
3. Surfaces of piles to a depth of at least 1'-0" below grade shall be painted with one coat of Carbomastic 615. Surface preparation shall be "Commercial Blast Cleaning" (SSPC – SP6). Any exposed areas that are marred during construction shall be touched up with Carbomastic 615. Feather or taper topcoats in damaged areas to be level with surrounding areas.

B. Lagging Installation:

1. Lagging shall be precast reinforced concrete panels, or as specified in the project plans.
2. Walls shall be backfilled with granular material. Backfill shall be placed and compacted in layers of not more than 6 inches and sloped as necessary to drain and prevent ponding during backfilling. Excavation shall not occur lower than the front (exposed) face proposed grade.
3. A continuous gravel drain wrapped in geotextile fabric shall be installed on the fill side of the wall at the elevation of the exposed face proposed grade. A weep hole shall be provided at each panel or in accordance with contract documents.

4.4 CRIB WALLS

- A. Crib walls shall be constructed of precast reinforced concrete members (headers and stretchers), or as specified in the project plans.**

B. Crib Wall Installation:

1. Crib walls shall be installed on a prepared base, such that the face of the wall is battered 2:12, and the base shall be sloped such that the top is perpendicular to the exposed face of the wall.
2. The wall shall be located so that no track tie will bear directly on any crib member.
3. Crib walls shall not exceed 20 feet in height.

4.5 TIE-BACK WALLS

- A. Tie-back walls shall be constructed in accordance with the plans and shall meet all applicable CSX Transportation Specifications and safety guidelines and AREMA recommendations.
- B. Tie-back walls shall generally not be used to support railroad track. No part of the tie-back or anchoring system may extend within the live load zone of influence of an active track unless approved by the ENGINEER.

4.6 REINFORCED CONCRETE CANTILEVERED WALLS

- A. Reinforced concrete cantilevered walls shall be constructed in accordance with the plans and shall meet all applicable CSX Transportation Specifications and safety guidelines and AREMA recommendations.
- B. Construction schedule shall ensure the minimal disruption to RAILROAD traffic.

PART 5 – MEASUREMENT AND PAYMENT

5.1 MEASUREMENT

- A. Measurement of retaining walls for payment shall be based on the type of wall constructed. If multiple wall types are used on the PROJECT, the measurement for each type shall conform to that individual wall type. Measurement for retaining walls, as shown on the plans, as specified in this section, and as accepted in the final work, shall be as follows:
 - 1. TIMBER RETAINING WALLS, on a LUMP SUM basis;
 - 2. STEEL SHEET PILING, on a per LINEAR FOOT basis of steel sheet piling driven. Length measured shall be from the top of pile elevation to the tip of pile elevation installed;
 - 3. SOLDIER PILE AND LAGGING RETAINING WALLS, on a per LINEAR FOOT basis, measured along the length of the wall;
 - 4. CRIB WALLS, on a LUMP SUM basis;
 - 5. TIE-BACK WALLS, on a LUMP SUM basis;
 - 6. REINFORCED CONCRETED CANTILEVERED WALLS, on a LUMP SUM basis.

5.2 PAYMENT

- A. Payment for retaining walls, measured as stated above, shall be full compensation for furnishing all labor, tools, materials, equipment, supplies, accessories, supervision, handling, disposal, engineering and all other expenses to furnish, unload, store, construct, drive or otherwise obtain correct depth, cut-off and dispose of cut-offs, and, if designated on plans, removing as required for steel sheet piling. Payment for each type of wall will be as follows:
 - 1. TIMBER RETAINING WALLS, at the contract price per LUMP SUM bid;
 - 2. STEEL SHEET PILING, at the contract unit price per LINEAR FOOT bid;
 - 3. SOLDIER PILE AND LAGGING RETAINING WALLS, at the contract unit price per LINEAR FOOT bid;
 - 4. CRIB WALLS, at the contract price per LUMP SUM bid;
 - 5. TIE-BACK WALLS, at the contract price per LUMP SUM bid;
 - 6. REINFORCED CONCRETED CANTILEVERED WALLS, at the contract price per LUMP SUM bid.

END OF SECTION 070305



PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section covers construction requirements, and measurement and payment for pile sockets used on CSX Transportation construction projects. Pile sockets covered by this specification include:
 - 1. Pre-drilled sockets necessary to install H-piles or other type of piles, in which the pile will be seated and backfilled in the pre-drilled socket. Where required, temporary casing shall be used to prevent caving of the drilled hole.
 - 2. Drilled sockets necessary to advance the driving of pipe piles into rock or other dense, hard material, in which the drilling auger is advanced from inside the pile.
- B. General conditions for this work are in accordance with Division 1 of the CSX Design and Construction Standard Specifications.

PART 2 - MATERIAL

2.1 GENERAL

- A. All materials shall meet the requirements of Division 7, 100 Series of the CSX Design and Construction Standard Specifications shown below:
 - Concrete070105
 - Steel.....070125

PART 3 - SUBMITTALS

3.1 SUBMITTALS

- A. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work.
 - 1. Material certifications
 - 2. Concrete mix for backfilling pile sockets
 - 3. Installation and construction plan
 - 4. Installation Equipment information

PART 4 - EXECUTION

4.1 PRE-DRILLED SOCKETS

- A. The depth of the pile socket shall be a minimum of 5 feet into competent rock. The diameter shall be as shown on the project plans or as directed by the Engineer.
- B. The pile socket shall be thoroughly cleaned prior to installation of the steel pile. The steel pile shall be placed into the rock socket and seated. After the steel pile has been seated, the hole for the pile socket shall be backfilled with concrete to the elevation shown on the Project Plans. If water is present in the pile socket or drilled hole, the concrete shall be placed according to Section 070105 of the CSX Design and Construction Specifications. The socket casing may be left in place if approved by the Engineer.
- C. Variations greater than ¼ inch per foot from vertical or the specified batter shall not be allowed. The horizontal deviation of the top of the piles shall not exceed one inch from the plan location.

- D.** Rotation of an H-pile from its centerline shall not exceed 5 degrees from its orientation shown on the plans.
- E.** Piles not meeting tolerance requirements or out of line as to impair usefulness, or piles that are damaged as to impair structural capacity, shall be pulled and reinstalled or an additional pile installed to provide added support.
- F.** The cost of reinstalling improperly installed pile or the cost of furnishing and installing an additional pile due to improper installation methods shall be borne solely by the contractor.

4.2 SOCKETS DRILLED TO ADVANCE PILE DRIVING

- A.** The depth and diameter of the pile socket shall be as shown on the project plans.
- B.** The pile shall be installed as shown on the project plans.

PART 5 – MEASUREMENT AND PAYMENT

5.1 MEASUREMENT

- A.** Measurement of PILE SOCKETS, XX DIAMETER for payment, as shown on the project plans, as specified in this Section and as accepted in the final work, shall be on a per LINEAR FOOT basis. The diameter of the pile socket shall be specified. Where pile sockets are predrilled, the measurement shall be from the ground surface to the pile tip elevation, as installed in the field. The cost of any casing required to prevent caving of the hole shall be incidental. Where pile sockets are used to advance driving a pipe pile, the measurement shall be from the pile tip at initial refusal to the pile tip at final tip elevation.

5.2 PAYMENT

- A.** Payment for PILE SOCKETS, XX DIAMETER, measured as stated above, will be at the contract unit price per LINEAR FOOT bid. Said unit price shall be full compensation for furnishing all labor, materials, tools, equipment, forms, supplies, accessories, supervision, engineering and all other items of expense to PILE SOCKETS, XX DIAMETER.

END OF SECTION 070405



MWI 901-06
Road Crossing Installation
Issued: 5/27/97 Revised: 1/26/12
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PURPOSE:	To establish a uniform procedure governing the construction and rehabilitation of road crossings and the selection of road crossing surface materials.
SAFETY:	Observe all applicable Safety, and Operating Rules and Regulations; and Safe Job Procedures.
LOCATION:	All CSXT owned or maintained tracks.
ENVIRONMENTAL:	Observe all applicable Federal, State and Local environmental rules and regulations.
REFERENCES:	Division Trackworks – Road Crossing Installation Standard Drawings: 2521, 2522, 2524, 2527, 2535, 2536, 2538, 2539 2602, 2613.

I. DISCUSSION

- A. Many crossings are covered by contracts. A review for contractual obligations should be made to ensure CSXT constructs the crossing as required and is reimbursed accordingly.
- B. Coordination with the proper governmental agency or outside party responsible for the crossing is essential.
 - 1. All street and road closures must be coordinated prior to closing.
 - 2. Proper barricades must be placed at all crossings during the time that they are closed to prohibit vehicles from entering the work zone. All state and local regulations must be met in the erection and installation of these barricades.
 - 3. Many States highway and local road departments have policies, which allow them to assist in providing barricades, detour routing, and/or paving at no cost to CSXT. In the initial contact with the governmental agency, arrangements must be made to obtain this assistance where available.
 - 4. A review of the highway traffic density, both current and projected, must be made during the planning for the project.
 - 5. In some cases the crossing to be repaired may be the only access and special arrangements must be made such as:

- a. Coordination with local resident/residents to leave their vehicle on the opposite side of the crossing.
 - b. Having material readily available to place in quickly to allow emergency vehicles access.
 - c. Constructing a temporary crossing.
 - d. Adjust work hours if necessary to accommodate special needs.
 6. See Planning and Installation Checklist attached to this instruction and provided as a separate document.
- C. The horizontal and vertical geometrics of highway crossings require special attention. It must be remembered that highway crossing areas are usually areas that have multiple ownership and that alignments may be dictated by the governmental organization that controls the highway. The following design concepts were extracted from the *Policy on Geometric Design of Highways and Streets*, published by the American Association of State Highway and Transportation Officials. They should be considered where appropriate for the anticipated usage, if practical.
1. Horizontal Alignment – If practical, the highway should intersect the track at right angle with no nearby intersections or driveways. This layout will enhance the vehicle driver's and locomotive operator's view of the crossing area, reduces conflicting vehicular movements from crossroads and driveways, and is preferred for two wheeled vehicles. To the extent practical, crossings should not be located on railroad or highway curves.
 2. Vertical Alignment – It is desirable from the standpoint of sight distance, ride ability, braking and acceleration distances that the crossing be made as level as practical. Vertical curves should be of sufficient length to ensure an adequate view of the crossing. In some instances, the roadway vertical alignment may not meet acceptable geometrics for a given design speed because of restrictive topography or limitations of right-of-way. As a recommended guideline, the crossing surface should be on the same plane as the top of rail for a distance of 30 inches outside the rails¹. The surface of the highway should also not be more than 3 inches higher or lower than the top of the nearest rail at a point 30 feet from the rail unless superelevation makes a different level appropriate. Tracks that are superelevated or a roadway approach that is not level, require site specific analysis.

II. CRITERIA REQUIRED FOR A QUALITY CROSSING

Road crossing construction and rehabilitation is resource intensive and disruptive to rail and highway traffic, therefore special care must be taken to ensure that the crossing is properly installed. The entire "Crossing Zone" requires special care and maintenance practices. The "Crossing Zone" is the crossing surface including all new required pavement and the track / right of way approaching the crossing for 50 feet each side of the crossing.

¹ High speed roadways (50MPH and greater) with considerable truck traffic (20% and greater) should have the level distance increased to 20 feet.

A. DRAINAGE

1. If the crossing is well drained and shows no signs of subgrade problems, extra care must be taken to ensure that drainage facilities and “hard pan” are not damaged. “Hard pan” is a densely compacted layer of ballast and other materials lying beneath the ties. It is relatively impervious and acts like a subballast layer. This layer must be located at a depth that will promote drainage and not pool water.
2. Good drainage must be provided from all four quadrants of the crossing and crossing zone. Ditches, pipes and/or French drains should be installed, if necessary, to obtain the adequate drainage. Check and maintain all existing pipes and ditches on the right-of-way that drain the crossing zone.
3. A level granular working area must be provided around highway crossing warning devices. If this area is excavated for drainage, it should be filled with free draining size #5 ballast (see MWI 301). Provisions must be made to protect buried cables. Normally a level area 6 feet to the front / side and 2 feet to the rear of the mast foundation is required for maintenance of gate or flasher mechanisms. Refer to drawing 2613 for details.
4. Roadway approaches and ditches should be sloped or diverted away from the crossing.
5. In cases where roadway descend to the crossing, other drainage mechanisms such as slot drains should be considered to divert as much water away from the crossing as possible.
6. If there is evidence of sub-grade problems, the stability must be improved. Consider using asphalt (HMA) underlayment, geogrids, or geotextiles. When these materials are used, they must be installed in accordance with the instructions contained in MWI 1003 or MWI 1004.

B. BALLAST

1. Ballast in the crossing must be granite or trap rock meeting CSXT Specifications (MWI 301).
2. **Ballast must be clean and free draining** both in cribs and under ties within the crossing. Tracks that have ties replaced or surfaced must have a minimum of 4 inches of ballast below bottom of tie after tamping is complete. Tracks that are renewed by panel method will comply with standard drawings (12 inches of ballast under the tie). Engineering judgment may be used to reduce the depth of ballast required under a panel based on existing site conditions; at no time should the depth of ballast be reduced to less than 4 inches under the crossties.
3. Ballast within the entire crossing zone must be clean. Ballast that is fouled with mud or debris can degrade the proper operation of crossing warning devices.
4. If ties are replaced in the crossing, the ballast must be renewed.

5. A sufficient quantity of ballast to perform crossing renewal and planned track raise must be available on site to prevent delay in restoring the track upon crossing installation.
6. Ballast cross section below bottom of tie which supports the track must be compacted solidly before the crossing surface and pavement approaches are placed. Preferred methods of compaction are:
 - a. Vibratory roller
 - b. Train traffic (4 tonnage trains or 20,000 tons accumulated minimum)
 - c. Dynamic Stabilizer
 - Cribs must be filled with ballast during operation.
 - 2 to 3 passes but shall not violate manufacturer's operating instructions.
7. The finished ballast cross-section in the crossing zone approaching the crossing must comply with Standard Drawing 2602. Care must be taken to ensure that no surplus ballast is present to impede drainage except as noted in paragraph II.A.3. above. Additional drainpipe may be required.

C. CROSSTIES

1. The old pavement should be saw cut three (3) feet from the rail. If ties are to be inserted, locate the saw cut on one side approximately six (6) feet from the rail or the minimum needed to install the ties. This will vary depending on site conditions and material used (panel installation, 8 foot 6 inch vs. 10 foot ties).
2. All ties through the entire crossing must be in a like new condition, wood, and provide consistent support. If any single tie needs to be replaced, it will be replaced with a new tie and all remaining ties through the entire crossing and the 5 approach ties must be in like new condition. If multiple locations of consecutive ties need to be replaced, then all ties within the crossing will be replaced. Branch line ties and relay ties will not be installed within the crossing.
3. If ties removed from the crossing are still sound, they may be reinstalled in tangent track.
4. Ten-foot wood ties are required for all full width concrete road crossing surfaces. These 10-foot wood ties must extend for a minimum of 10 ties beyond each end of crossing
5. Crossings in concrete tie territory are to be constructed on 10-foot long wood ties with positive restraint fasteners and plates. These 10-foot wood ties must extend for a minimum of 10 ties beyond each end of crossing as a transition to concrete ties. The use of clips with corrosion prevention coating should be considered.
6. Ties should be installed using the most appropriate method for the particular crossing. Normal methods include:
 - a. Mechanized tie installation equipment
 - b. Pre-plated ties (see drawing 2532)
 - c. Tie packs (see drawing 2526)
 - d. Track Panels (see drawing 2515)

7. During tie replacement or track panel construction, the ties will be placed on 19 - ½ inch centers for rubber interface, timber, and concrete crossings. Other manufacturers of crossing surfaces may require ties to be installed at different centers, generally 18 inch.
8. Tie plates / fasteners should prevent rail movement and rotation. Tie plates must be replaced if worn beyond the limits shown below:
 - Shoulder height 11/32 inch minimum
 - Rail seat width (6 in. base rail) 6-1/4 inches maximum
 - Rail seat width (5-1/2 in. base rail) 5-3/4 inches maximum
 - Spike hole size 27/32 inch maximum
 - Plate thickness at edge 11/32 inch minimum
 - Rail seat flatness 1/16 inch maximum convex
 - Plate bottom flatness 1/8 inch maximum convex
9. All ties in the crossing are to be spiked with two rail-holding spikes on the gage side and two on the field side. If the plates do not have the rail holding positions then plates will be replaced. Positive restraint fastener plates will be installed per standard drawing 2512.

D. RAIL

1. Rail should be replaced if existing rail:
 - a. has surface imperfections
 - b. is surface bent
 - c. has less than 9 years of expected life
 - d. is programmed for renewal within the crossings expected service life
 - e. has excessive base wear or nicks (limits are)
 - base width (6" base rail) 5-7/8 inches minimum
 - base width (5-1/2" base rail) 5-3/8 inches minimum
 - notching in base not visible
2. No bolted rail joints are allowed in the crossing.
3. Thermite welds may not be located within the crossing on main tracks and sidings and should not be located within crossings on other tracks.
4. No bolted rail joints are allowed within the Crossing Zone on main, branch or siding tracks, where the rail is greater than 110 lbs/yd. They may be closer to the crossing on other tracks at the discretion of the Division Engineer.
5. Only bonded insulated joints are permitted in the Crossing Zone on main, branch or siding tracks.
6. Bolted joints within the Crossing Zone must be welded out as soon as possible.
7. Thermite welds in the crossing zone due to rail replacement or panel installation must be

made within 3 days.

8. Thermite welds in the crossing zone should be staggered and at least 10 feet away from the edge of the crossing, and supported by good ties.
9. Ensure that the rail anchoring pattern is correct. See MWI 703.

E. SURFACING

1. If practicable in multiple track crossings, all tops of rail should be brought to the same plane.
2. The minimum practical track raise should be used to limit its effect on the highway profile. Coordinate with the proper governmental agency or outside party responsible for the crossing as necessary.
3. Crossings should be surfaced so that at least one future surfacing cycle can be performed without the crossing being left lower than the surrounding track. The track runoff will be located outside the crossing zone.
4. Solid tamping is important. The tamper must use double insertions and, if capable, tamp the total length of the tie. Care must be taken to avoid center binding of the tie.
5. When track is tamped, ballast **MUST** be compacted before the crossing surface and pavement are placed. Preferred methods of compaction are:
 - a. Train traffic overnight (4 tonnage trains or 20,000 tons minimum)
 - b. Dynamic Stabilizer (2 to 3 passes for 50 feet each side of crossing but shall not violate manufacturer's operating instructions)
6. The finished ballast cross-section in the crossing zone approaching the crossing must comply with Standard Drawing 2602 with no surplus ballast to impede drainage except as noted in paragraph II.A.3. Permitted cross-section tolerances for track maintenance work are given in MWI 1113, section H.

F. TEMPORARY CROSSING

1. Ballast & Cold Mix
 - a. Must be of sufficient quantity and strength to support the expected road traffic.
 - b. Cold mix must be removed from the track as soon as it is not needed. Use a double or triple layer of filter fabric to aide in removing cold mix while keeping ballast clean.
 - c. Ballast must be standard CSXT specification for main track. Other materials are not permitted.
2. Modular Temporary Crossing
 - a. Must be of sufficient size and strength to support the expected road traffic.
 - b. Must be secured to track.

G. CROSSING SURFACE MATERIAL AND INSTALLATION

1. Material:
 - a. There are several CSXT Standard Road Crossing designs. Unless the crossing is covered by an agreement/contract, the Standard design will be determined during the preplanning inspection. The Division Engineer will select the appropriate Standard design for other projects.
 - b. A heavy duty crossing surface is justified on heavy vehicular traffic roads.
 - c. See Section III for details on available crossing surface materials.
2. General installation:
 - a. The ends of rubber interface sections, located in traffic lanes, must be supported on a tie.
 - b. Concrete and other crossing surface materials should be installed according to the manufacturer's instructions.
 - c. Where truck traffic is considerable (20% and greater), a concrete header or apron may be considered. This is placed adjacent to the concrete crossing surface to absorb impact.
 - d. Spike at end of crossing on both sides should be heeled over to secure wood filler blocks or rubber interface from sliding out. The wood filler blocks or rubber interface will most likely move in the direction with the greatest traffic.

H. ASPHALT PAVEMENT

1. The paving contractor will saw cut the existing pavement before the reconstruction. See Section II.C.1 for location criteria.
2. The crossing surface will extend a minimum of two (2) feet beyond the edge of the existing roadway / sidewalk or comply with state regulations, whichever is greater. Other widths must have the approval of the Director Engineering Standards or the Division Engineer.
3. Estimated quantity of asphalt pavement should be accurate to ensure quality and minimize waste. Saw cutting of asphalt prevents unintentional removal of material; therefore cut asphalt for tie replacement approximately 6 feet from the edge of rail on tie installation side and 3 feet on the opposite side. For this kind of work, estimate 0.9 ton per linear track foot. For routine surface work through crossing saw cut at 3 feet from the rail on both sides. For this kind of work, estimate 0.7 ton per linear track foot.
4. Ballast under the asphalt pavement must fill in the cribs including under the rubber or timber flangeway and field interface sections. Shoulder ballast must be level with top of tie and compacted with vibratory equipment by the asphalt-paving contractor prior to paving.

5. Asphalt pavement should be full depth between top of tie and road surface except for farm / residential crossings. Compacted pavement must be thick enough to lock into the rubber interface material.
6. Tack coat must be used where new asphalt meets old pavement. The Tack must meet the state D.O.T. specifications for the state in which the crossing is located.
7. Asphalt (bituminous concrete) pavement used must be a dense-graded mix, which meets the state D.O.T. specifications for asphalt pavement construction for the state in which the crossing is located. Certificates must be given to the Roadmaster.
 - a. Use base or binder mix for all but the top two (2) inches of the pavement cross-section.
 - b. Use surface mix for the top wearing surface only (Two inches thick maximum). Base or binder mix may be used for the entire depth of pavement on farm / residential crossings.
 - c. The asphalt pavement must be compacted in a minimum of 2 lifts (4 inch maximum per lift).
8. Asphalt pavement material must be sufficiently hot (minimum 200°F) for proper compaction. Optimal temperature is greater than 250°F.
9. The roller used to compact the asphalt should be a steel-wheeled vibratory type. It must be narrow enough to fit between the gage side flangeway interface material and between the outside of the crossing and old pavement. It should exert a minimum force of 12,000 lb/roll at 2400 vpm and operated at a speed of less than 3 ft/sec. Normally, a 36-inch vibratory roller will meet this criteria. A roller with equivalent compaction force but less than 26" wide must be used between the rails on a Rubber / Asphalt / Timber (RAT) or Timber / Asphalt type crossing.
10. The roller must be operated parallel to the rail and up against the rubber, concrete, or timber surface material to ensure good asphalt compaction. Use caution not to dislodge rubber interface sections or the clamps / spikes that secure the rubber.
11. Asphalt should be compacted to at least 91% of maximum theoretical density (air voids less than 5% in the compacted mix). For quality assurance, asphalt core borings may be taken to verify compliance.
12. Paved road surface should be level with the top of rail for 30 inches from the field side of each rail unless there is a conflict with State regulations. In case of a conflict, the State regulations will govern. For new construction, highway surface should not be more than 3 inches higher or lower than the top of the near rail 30 feet from the rail along the road centerline, unless track superelevation dictates otherwise. If practicable, slope the pavement 1 inch in 10 feet to meet existing highway surface. On high speed roads (50MPH and greater), the surface may have to be even smoother to reduce impacts on the crossing surface. High speed roadways with considerable truck traffic (20% and greater) should have the level distance increased to 20 feet.

13. On unpaved roads, the asphalt pavement on the field side of the rail must be of sufficient volume so it does not move or slip away from the rail under the expected roadway traffic. State regulations may require a minimum length “apron”.
14. The crossing should be closed to highway traffic long enough for the hot asphalt pavement to cool (hand touchable) and stiffen to support loads without rutting.
15. The old pavement removed may not always be the same amount that was delivered for the current paving project. For example, the maximum thickness should be approximately 8” for any paving project. Depending on rail height, the *average* crossing timber is 8”. If a previous paving project had a thicker pavement section due to insufficient fill material (e.g. ballast), the amount of pavement removed will be greater than what was delivered if done correctly with sufficient fill material. This should be noted on the paving invoice.
16. Old pavement, ballast, and surface material must be disposed of in a proper manner complying with CSXT policies. Refer to Environmental Guidelines manual.
 - a. Different materials must be handled separately for removal or stockpile at CSX designated sites.
 - b. Asphalt pavement with only some ballast stuck to the bottom may be a recyclable material so keep it as clean as possible.
 - c. Solid waste containers are available if needed. Contact 800-633-6085.

I. QUALITY ASSURANCE

1. Crossing rehabilitation or construction is to be performed to meet these instructions. Failure of rail, track surface and gage, or roadway surface should not occur within the intended maintenance cycle. Either Engineering or Purchasing and Materials may direct or perform sample inspections of the following activities or materials:
 - Drainage
 - Ballast
 - Ties
 - Crossing material
 - Pavement (asphalt may be cored to verify material characteristics and density)
 - Rail and welding
2. If a crossing fails before its intended maintenance cycle and it requires a speed restriction for rail traffic or a detour for vehicular traffic, a report will be made by the Engineer-Track to the following people:
 - Chief Engineer - Maintenance of Way
 - Assistant Chief Engineer - Production
 - Division Engineer
 - Director Engineering Standards.

The report should describe the problem and contain photographs.

J. POSITIVE TRAIN CONTROL

1. It is best practice to reference the end of an existing road crossing surface with marking the rail with paint before removing the existing material. If multiple tracks (e.g. double main line) are being worked on, mark the location of the end of each road crossing using paint for both rails.
2. Any road crossing whose length changes greater than one foot (1') must enter a change request per MWI 2114.

III. MATERIAL SELECTION

(Also refer to drawings 2521, 2522, 2524, 2527, 2535, 2536, 2538 and 2539)

CSXT has six (6) standard crossing surfaces for wood tie installations. There are 4 basic levels of service based on the amount and severity of the highway crossing traffic. They are:

1. Heavy Duty (1 design, drawing 2527)
2. Normal Duty (3 designs, drawings 2535, 2536, and 2538)
3. Light Duty (1 design, drawing 2521)
4. Farm / Residential Use (2 designs, drawings 2522 and 2536)

There is no specific criteria as to which crossing design should be used, and discretion should be exercised on a case by case basis, but generally, the heavier the truck traffic, the faster the highway speed, or the higher the railroad tonnage is, the more durable the crossing should be. Consideration should be given to consider the recommendation of state and local authorities if they have expressed it. Refer to the paragraphs below for more information. Factors to consider are:

1. Severity of interrupting the railroad
2. Severity of interrupting the highway
3. Railroad tonnage and speed
4. Highway vehicle traffic count
5. Highway vehicle weights
6. Highway vehicle speed

Many Highway Departments measure traffic or vehicle count as AADT (Average Annual Daily Traffic) and Truck AADT (Truck Average Annual Daily Traffic). If this data is available, use it in conjunction with the following chart. When using this method, one truck equals 100 cars.

The governmental agency or outside party responsible for the road at the crossing should be contacted to determine vehicle count. For light duty, private, farm and residential crossings, gather information from the person contacted to close the crossing.

The type of crossing material selected should generally follow the chart below:

HIGHWAY TRAFFIC

RAILROAD TRAFFIC

<u>Cars per Day*</u>	<u>0 – 10 MGT / year</u>	<u>10+ MGT / year</u>
0 – 50,000	Normal Duty (Rubber / Asphalt / Timber) See paragraph A2 Normal Duty (Timber / Asphalt) A3 [1] Light Duty (Rubber / Asphalt) A4 [2] Farm Duty (Rubber / Asphalt) A5 [2] Farm Duty (Timber / Asphalt) A6	Normal Duty (Rubber / Asphalt / Timber) See paragraph A2 Normal Duty (Timber / Asphalt) A3 [2] Farm Duty (Timber / Asphalt) A6
50,000 – 100,000	Normal Duty (Rubber / Asphalt / Timber) A2 Normal Duty (Timber / Asphalt) A3	Heavy Duty (Concrete on 10' wood ties) A1 Normal Duty (Rubber / Asphalt / Timber) A2 Normal Duty (Timber / Asphalt) A3
100,000+	Heavy Duty (Concrete on 10' wood ties) A1	Heavy Duty (Concrete on 10' wood ties) A1

*** When calculating cars per day, multiply each truck by 3,333.**

[1] Crossing must handle less than 5000 cars per day.

[2] Crossing must handle less than 3,333 cars per day.

If track warrants Positive Restraint Fasteners (Pandrol or NorFast Plates), use Heavy Duty Concrete (A1) or Light Duty Rubber / Asphalt (A4) as appropriate.

A. WOOD TIE INSTALLATIONS – CSXT has designs for heavy, normal, light duty and farm / residential duty applications for crossings. These designs use various combinations of concrete, timber, or rubber interface and asphalt pavement material.

1. Heavy Duty Highway Crossings (Concrete) – Shown on CSXT Standard Drawing number 2527. This crossing material consists of 8 ft. 1-1/2 in. long concrete center (gage) and field panels. They must be installed on 10 ft. ties.

The catalog information follows:

<i>Stock Control Number</i>	<i>Rail Weight</i>	<i>Description</i>
014.5250300.1	115 – 122	Crossing Concrete Panels, Heavy Duty, for 10-foot wood ties. Order by “Track Feet” in approximately. 8-ft. increments. Each 8-ft. 1-1/2 in. section incl. 1 concrete center panel and 2 concrete field panels with rubber flangeway fillers.
014.5250305.1	132 – 136	
014.5250310.1	141	

Approximate weights of these panels are:

Center Panel, 115 – 122 lb. rail	2850 pounds
Field Panel, 115 – 122 lb. rail	1550 pounds

Center Panel, 132 – 141 lb. rail	3125 pounds
Field Panel, 132 – 141 lb. rail	1675 pounds

The heavy duty concrete crossing design should be used where the preponderance of the highway traffic is composed of trucks, where the environmental or other concerns for the disposal of asphalt must be minimized and/or where maintenance history indicates a need for its use.

2. Normal Duty Highway Crossing (Rubber / Asphalt / Timber) (RAT) – Shown on CSXT Standard Drawing number 2535. This design uses 10 inch wide by 8 ft. 1-1/2 in. long wooden timbers that are placed against rubber interface material adjacent to the rails. The timbers are attached to the ties with timber screws. This will give the crossing more strength. Clamps for the rubber interface are not needed. Full depth compacted asphalt pavement is used for the remaining road surface area. The rubber interface material should be reused from existing crossings. Do not requisition new rubber. If rubber is not available, use the Timber / Asphalt design with wooden filler blocks described in the following paragraph no. 3. The catalog information for the RAT crossing timber follows:

<i>Stock Control Number</i>	<i>Rail Weight</i>	<i>Description</i>
042.1150010.1	115 – 122	Crossing Timbers 7-1/2" thick 8' 1-1/2" long per CSX drawing 2535. Four timbers per bundle (2 gage, 2 field). Use with rubber rail seal. Order by "Track Feet" in 8-ft. increments.
042.1320010.1	132	Crossing Timbers 8" thick 8' 1-1/2" long per CSX drawing 2535. Four timbers per bundle (2 gage, 2 field). Use with rubber rail seal. Order by "Track Feet" in 8-ft. increments.
042.1360010.1	136 – 141	Crossing Timbers 8-3/8" thick 8' 1-1/2" long per CSX drawing 2535. Four timbers per bundle (2 gage, 2 field). Use with rubber rail seal. Order by "Track Feet" in 8-ft. increments.
013.8230080.1	all	Screw Timber 5/8" X 12" with Torx square washer head.

3. Normal Duty Highway Crossing (Timber / Asphalt) – Shown on CSXT Standard Drawing number 2536. This design uses 10 inch wide by 8 ft. 1-1/2 in. long wooden timbers with wooden filler blocks adjacent to the rails. The timbers are attached to the ties with timber screws. Full depth compacted asphalt pavement is used for the remaining road surface area. The catalog information for this timber follows:

<i>Stock Control Number</i>	<i>Rail Weight</i>	<i>Description</i>
042.3060115.1	115	Crossing Timbers 7-1/2" thick 8' 1-1/2" long with wood filler blocks per CSX drawing 2536. Four timbers per bundle.

<i>Stock Control Number</i>	<i>Rail Weight</i>	<i>Description</i>
		Order by "Track Feet" in 8-ft. increments.
042.3060122.1	122	Crossing Timbers 7-1/2" thick 8' 1-1/2" long with wood filler blocks per CSX drawing 2536. Four timbers per bundle. Order by "Track Feet" in 8-ft. increments.
042.1320132.1	132	Crossing Timbers 8" thick 8' 1-1/2" long with wood filler blocks per CSX drawing 2536. Four timbers per bundle. Order by "Track Feet" in 8-ft. increments.
042.1360136.1	136	Crossing Timbers 8-3/8" thick 8' 1-1/2" long with wood filler blocks per CSX drawing 2536. Four timbers per bundle. Order by "Track Feet" in 8-ft. increments.
042.1360140.1	140	Crossing Timbers 8-3/8" thick 8' 1-1/2" long with wood filler blocks per CSX drawing 2536. Four timbers per bundle. Order by "Track Feet" in 8-ft. increments.
042.1360141.1	141	Crossing Timbers 8-3/8" thick 8' 1-1/2" long with wood filler blocks per CSX drawing 2536. Four timbers per bundle. Order by "Track Feet" in 8-ft. increments.
013.8230080.1	all	Screw Timber 5/8" X 12" with Torx square washer head.

4. Normal Duty Highway Crossing (Timber/Asphalt) for use with 18" tie plates--) – Shown on CSXT Standard Drawing number 2538. This design uses a 10 inch wide by 6 ft. 8-1/2 inch. long wooden timber with wooden filler blocks adjacent to the rails for the gage side and a 16-1/2 inch wide by 6 ft. 8-1/2 inch long wooden timber with wooden filler block for the field side. The timbers are attached to the ties with timber screws. Full depth compacted asphalt pavement is used for the remaining road surface area. The catalog information for this timber follows:

<i>Stock Control Number</i>	<i>Rail Weight</i>	<i>Description</i>
042.3060122.1	122	Crossing Timbers 7-1/2" thick 6.75' long with wood filler blocks per CSX drawing 2538. Four timbers per bundle. Order by "Track Feet" in 6.75-ft. increments.
042.1320132.1	132	Crossing Timbers 8" thick 6.75' long with wood filler blocks per CSX drawing 2538. Four timbers per bundle. Order by "Track Feet" in 6.75-ft. increments.
042.1360136.1	136	Crossing Timbers 8-3/8" thick 6.75' long with wood filler blocks per CSX drawing

<i>Stock Control Number</i>	<i>Rail Weight</i>	<i>Description</i>
		2538. Four timbers per bundle. Order by "Track Feet" in 6.75-ft. increments.
042.1360140.1	140	Crossing Timbers 8-3/8" thick 6.75' long with wood filler blocks per CSX drawing 2538. Four timbers per bundle. Order by "Track Feet" in 6.75-ft. increments.
042.1360141.1	141	Crossing Timbers 8-3/8" thick 6.75' long with wood filler blocks per CSX drawing 2538. Four timbers per bundle. Order by "Track Feet" in 6.75-ft. increments.
015.0001283.1	all	Bit Drill Step 11/16" With 3/8" Pilot 18" Overall Length
013.8230080.1	all	Screw Timber 5/8" X 12" with Torx square washer head.
451.0076810.1	all	Bit Torx adapter Insert 5/8" Impact 1" Drive

5. Light Duty Highway Crossings (Rubber / Asphalt) – Shown on CSXT Standard Drawing numbered 2521. This design uses rubber interface material with full depth compacted asphalt pavement on the both sides of the rails. It is only permitted on tracks with less than 10 annual MGTs and highways less than 5,000 Cars per Day. Existing rubber interface material should be used where available. Avoid purchasing new rubber and consider using concrete or timber / asphalt designs. Do not requisition new rubber unless authorized by the Division Engineer or System Production Manager.

The catalog information follows:

<i>Stock Control Number</i>	<i>Rail Weight</i>	<i>Description</i>
014.5250135.1	90 – 100	Crossing, Rubber Interface Light duty, for wood ties. Order by "Track feet" in 8 ft. increments. Each "Track foot" includes 2 gage side and 2 field side sections.
014.5250140.1	115	
014.5250142.1	122	
014.5250145.1	132	
014.5250147.1	136	
014.5250160.1	140	
014.5250170.1	141	Clip/Clamp which may be used to secure rubber. Use in each crib.
014.5250260.1	90 – 141	
014.0041400.1	132 – 136	
014.5250175.1	141	Crossing, Rubber Interface Light duty for Pandrol plates on wood ties.
014.5250250.1	132 – 141	Clip/Clamp which should be used to secure rubber interface on Pandrol plates.
014.5250265.1		Installation tool for Clip/Clamps

6. Farm / Residential Road Crossings (Rubber / Asphalt) – These very light duty road crossings are defined as private roads, city streets and with vehicular traffic speeds of 25 MPH and lower and with less than 500 Cars per day. This design is not permitted if trucks use the crossing. If the road will be handling trucks, use one of the previous designs. It is only permitted on tracks less than 10 annual MGTs. See CSXT Standard Drawing number 2522. This design uses lighter weight virgin rubber or used rubber field and flangeway interface material, with a minimum of four (4) inches of compacted asphalt.
 7. Farm / Residential Crossings (Timber / Asphalt) – These are private crossings that conform to very light duty traffic criteria, and serve a limited number of users. Examples would be a road connecting two farm fields, a road providing access to an individual home, or an infrequently used access to a commercial site, such as a billboard or pumping station. The limited service requirements of these crossings allow the use of cascaded materials and minimization of asphalt quantities. Crossing material should be economized at these locations. The design is similar to the T / A crossing (Drawing 2536) but uses less asphalt pavement. Use the following guidelines:
 - a. Use second hand wood material if available or order material described for Standard Duty crossings.
 - b. In crossings not susceptible to frost heave such as areas below TN & NC, compacted asphalt pavement thickness to be 3 inches minimum to 4 inches maximum.
 8. Former Normal Duty Highway Crossing (Concrete / Rubber / Asphalt) – This former standard, shown on CSXT Standard Drawing number 2524 uses a concrete panel with rubber flangeway filler between the rails and rubber interface material with full depth compacted asphalt pavement on the field sides of the rails. If the crossing material is in good condition and the crossing has performed satisfactorily, it may be reinstalled. If the material is in good condition but the asphalt pavement broke up, use the crossing material in a lower duty crossing or add timbers against the rubber like the RAT crossing design for added strength.
- B. Private crossings will be considered the same as a public crossing with similar traffic volumes. Some private crossings, such as concrete plant entrances, will usually have heavy truck traffic. These industrial crossings should use normal or heavy duty material.
- C. Care must be taken to ensure that the correct type of rubber interface material is installed. Manufacturer's warranty (minimum of 10-year life) can only be honored if the rubber interface material is properly matched to the highway traffic conditions.
- D. All other crossing other crossing materials installed on CSXT owned and/or maintained tracks must be approved by the Office of Director Engineering Standards. Road crossings, which are funded by Outside Parties, may be constructed with concrete slab or full depth rubber if specified by the Outside Party. The crossing surfaces that are currently approved are:

- Omni Improved CSX/IC Design Concrete
- KSA Full Width Concrete with Steel Perimeter
- Magnum Concrete
- Omni Heavy Duty Full Depth Rubber
- HiRail Full Depth Rubber

Platform (tieless, modular, or tub) type crossings are approved where track speeds do not exceed 15 MPH. These types of crossings should have 10 each 10' wood crossties on both approaches to transition to open track. Other applications of platform crossings must include a feasibility analysis with arrangements for inspection and approval from the Office of Director Engineering Standards prior to installation. Approved designs are:

- R. W. Summers – MBM
- Oldcastle Startrack II
- OMNI TraCast
- Hanson Premier Plus Modules

Refer to drawing 2539 for additional specifications. If the outside party desires to use another premium crossing, prior arrangements and approval must be obtained from the Office of Director Engineering Standards.

- E. Other crossing designs or materials such as composites, if approved by the Director Engineering Standards, may be considered on an individual location basis.
- F. Field side grinding relief is not required in any crossing surface.
- G. Rubber interface material is to be ordered by the track foot for a specific crossing and installed at that location. An inventory of rubber material will not be kept on an individual Roadmaster's territory. Purchasing and Materials will identify inventory locations.
- H. When material is ordered for crossings with positive restraint fasteners on wood ties, care must be taken to order material specifically designed to accommodate these fastening systems. The use of clips with corrosion prevention coating should be considered.

Prepared by: Mark E. Austin
Engineer Standards II

Reviewed by: 
Director – Engineering Standards

Approved by: 
Assistant Vice President – Engineering

Office of the Vice President, Engineering
Jacksonville, Florida



APPENDIX A

CSX DESIGN AND CONSTRUCTION

STANDARD SPECIFICATIONS

Note: For all CSX specifications, the MEASUREMENT and PAYEMENT terms are replaced with:

- 1) Measurement of the work of this section will be in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITIY SUMMARY of the plans.
- 2) Payment of the work of this section will be included in the payment(s) for the applicable “Pay Item” and in accordance with the “Method of Measurement and Payment” description as included in PAY ITEM DESCRIPTION & ESTIMATED QUANTITIY SUMMARY of the plans.



APPENDIX B

REQUIREMENTS FOR WORK ON, OVER, OR WITH THE POTENTIAL TO IMPACT CSX PROPERTY

Note: The requirements of this Appendix are applicable to the Contractor's "Means and Methods" for planning, submissions, approvals and execution of the work.

Measurement and Payment for items as required will be included in other pay items. See PAY ITEM DESCRIPTION & ESTIMATED QUANTITY SUMMARY of the plans.

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APPENDIX B

REQUIREMENTS FOR WORK ON, OVER, OR WITH THE POTENTIAL TO IMPACT CSX PROPERTY

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INTRODUCTION

The intent of this document is to guide outside agencies and their Contractors when performing work on, over, or with potential to impact CSXT property (ROW). Work plans shall be submitted for review to the designated CSXT Engineering Representative for all work which presents the potential to affect CSXT property or operations; this document shall serve as a guide in preparing these work plans. All work shall be performed in a manner that does not adversely impact CSXT operations or safety; as such, the requirements of this document shall be strictly adhered to, in addition to all other applicable standards associated with the construction. Applicable standards include, but are not limited to, CSXT Standards and Special Provisions, CSXT Insurance Requirements, CSXT Pipeline Occupancy Criteria, as well as the governing local, county, state and federal requirements. It shall be noted that this document and all other CSXT standards are subject to change without notice, and future revisions will be made available at the CSXT website: www.csx.com.

I. DEFINITIONS

1. *Agency*— The project sponsor (i.e., State DOT, Local Agencies, Private Developer, etc.)
2. *AREMA*— American Railway Engineering and Maintenance-of-Way Association—the North American railroad industry standards group. The use of this term shall be in specific reference to the AREMA Manual for Railway Engineering.
3. *Construction Submission*— The Agency or its representative shall submit six (6) sets of plans, supporting calculations, and detailed means and methods procedures for the specific proposed activity. All plans, specifications, and supporting calculations shall be signed/sealed by a Professional Engineer as defined below.
4. *Controlled Demolition*— Removal of an existing structure or subcomponents in a manner that positively prevents any debris or material from falling, impacting, or otherwise affecting CSXT employees, equipment or property. Provisions shall be made to ensure that there is no impairment of railroad operations or CSXT's ability to access its property at all times.
5. *Contractor*— The Agency's representative retained to perform the project work.
6. *Engineer*— CSXT Engineering Representative or a GEC authorized to act on the behalf of CSXT.
7. *Flagman*— A qualified CSXT employee with the sole responsibility to direct or restrict movement of trains, at or through a specific location, to provide protection for workers.
8. *GEC*— General Engineering Consultant who has been authorized to act on the behalf of CSXT.
9. *Horizontal Clearance*— Distance measured perpendicularly from centerline of any track to the nearest obstruction at any elevation between TOR and the maximum vertical clearance of the track.

10. *Professional Engineer* – An engineer who is licensed in State or Commonwealth in which the project is to occur. All plans, specifications, and supporting calculations shall be prepared by the Licensed Professional Engineer and shall bear his/her seal and signature.
11. *Potential to Foul* – Work having the possibility of impacting CSXT property or operations; defined as one or more of the following:
 - a. Any activity where access onto CSXT property is required.
 - b. Any activity where work is being performed on CSXT ROW.
 - c. Any excavation work adjacent to CSXT tracks or facilities, within the Theoretical Railroad Live Load Influence Zone, or where the active earth pressure zone extends within the CSXT property limits.
 - d. The use of any equipment where, if tipped and laid flat in any direction (360 degrees) about its center pin, can encroach within twenty five feet (25'-0") of the nearest track centerline. This is based upon the proposed location of the equipment during use, and may be a function of the equipment boom length. Note that hoisting equipment with the potential to foul must satisfy the 150% factor of safety requirement for lifting capacities.
 - e. Any work where the scatter of debris, or other materials has the potential to encroach within twenty five feet (25'-0") of the nearest track centerline.
 - f. Any work where significant vibration forces may be induced upon the track structure or existing structures located under, over, or adjacent to the track structure.
 - g. Any other work which poses the potential to disrupt rail operations, threaten the safety of railroad employees, or otherwise negatively impact railroad property, as determined by CSXT.
12. *ROW* – Right of Way; Refers to CSXT Right-of-Way as well as all CSXT property and facilities. This includes all aerial space within the property limits, and any underground facilities.
13. *Submission Review Period* - a minimum of thirty (30) days in advance of start of work. Up to thirty (30) days will be required for the initial review response. Up to an additional thirty (30) days may be required to review any/all subsequent submissions or resubmission.
14. *Theoretical Railroad Live Load Influence Zone* – A 1 horizontal to 1 vertical theoretical slope line starting at bottom corner of tie.
15. *TOR* – Top of Rail. This is the base point for clearance measurements. It refers to the crown (top) of the steel rail; the point where train wheels bear on the steel rails.
16. *Track Structure* – All load bearing elements which support the train. This includes, but is not limited to, the rail, ties, appurtenances, ballast, sub-ballast, embankment, retaining walls, and bridge structures.
17. *Vertical Clearance* – Distance measured from TOR to the lowest obstruction within six feet (6'-0") of the track centerline, in either direction.

II. GENERAL SUBMISSION REQUIREMENTS

- A. A construction work plan is required to be submitted by the Agency or its Contractor, for review and acceptance, prior to accessing or performing any work with Potential to Foul.
- B. The Agency or its representative shall submit six (6) sets of plans, specifications, supporting calculations, and detailed means and methods procedures for the specific proposed work activity.
- C. Construction submissions shall include all information relevant to the work activity, and shall clearly and concisely explain the nature of the work, how it is being performed, and what measures are being taken to ensure that railroad property and operations are continuously maintained.
- D. All construction plans shall include a map of the work site, depicting the CSXT tracks, the CSXT right of way, proposed means of access, proposed locations for equipment and material staging (dimensioned from nearest track centerline), as well as all other relevant project information. An elevation drawing may also be necessary in order to depict clearances or other components of the work.

E. Please note that CSXT will not provide pricing to individual contractors involved in bidding projects. Bidding contractors shall request information from the agency and not CSXT.

F. The Contractor shall install a geotextile fabric ballast protection system to prevent construction or demolition debris and fines from fouling ballast. The geotextile ballast protection system shall be installed and maintained by the Contractor to the satisfaction of the Engineer.

G. The Engineer shall be kept aware of the construction schedule. The Contractor shall provide timely communication to the Engineer when scheduling the work such that the Engineer may be present during the work. The Contractor's schedule shall not dictate the work plan review schedule, and flagging shall not be scheduled prior to receipt of an accepted work plan.

H. At any time during construction activities, the Engineer may require revisions to the previously approved procedures to address weather, site conditions or other circumstances that may create a potential hazard to rail operations or CSXT facilities. Such revisions may require immediate interruption or termination of ongoing activities until such time the issue is resolved to the Engineer's satisfaction. CSXT and its GEC shall not be responsible for any additional costs or time claims associated with such revisions.

I. Blasting will not be permitted to demolish a structure over or within CSXT's right-of-way. When blasting off of CSXT property but with Potential to Foul, vibration monitoring, track settlement surveying, and/or other protective measures may be required as determined by the Engineer.

J. Blasting is not permitted adjacent to CSXT right-of-way without written approval from the Chief Engineer, CSXT.

K. Mechanical and chemical means of rock removal must be explored before blasting is considered. If written permission for the use of explosives is granted, the Agency or Contractor must submit a work plan satisfying the following requirements:

1. Blasting shall be done with light charges under the direct supervision of a responsible officer or employee of the Agency or Contractor.
2. Electronic detonating fuses shall not be used because of the possibility of premature explosions resulting from operation of two-way train radios.
3. No blasting shall be done without the presence of an authorized representative of CSXT. Advance notice to the Engineer is required to arrange for the presence of an authorized CSXT representative and any flagging that CSXT may require.
4. Agency or Contractor must have at the project site adequate equipment, labor and materials, and allow sufficient time, to clean up debris resulting from the blasting and correct any misalignment of tracks or other damage to CSXT property resulting from the blasting. Any corrective measures required must be performed as directed by the Engineer at the Agency's or Contractor's expense without any delay to trains. If Agency's or Contractor's actions result in the delay of any trains including passenger trains, the Agency or Contractor shall bear the entire cost thereof.
5. The Agency or Contractor may not store explosives on CSXT property.
6. At any time during blasting activities, the Engineer may require revisions to the previously approved procedures to address weather, site conditions or other circumstances that may create a potential hazard to rail operations or CSXT facilities. Such revisions may require immediate interruption or termination of ongoing activities until such time the issue is resolved to the Engineer's satisfaction. CSXT and its GEC shall not be responsible for any additional costs or time claims associated with such revisions.

III. HOISTING OPERATIONS

A. All proposed hoisting operations with Potential to Foul shall be submitted in accordance with the following:

1. A plan view drawing shall depict the work site, the CSXT track(s), the proposed location(s) of the lifting equipment, as well as the proposed locations for picking, any intermediate staging, and setting the load(s). All locations shall be dimensioned from centerline of the nearest track. Crane locations shall also be dimensioned from a stationary point at the work site for field confirmation.
2. Computations showing the anticipated weight of all picks. Computations shall be made based upon the field-verified plans of the existing structure. Pick weights shall account for the weight of concrete rubble or other materials attached to the component being removed; this includes the weight of subsequent rigging devices/components. Rigging components shall be sized for the subsequent pick weight.
3. All lifting equipment, rigging devices, and other load bearing elements shall have a rated (safe lifting) capacity that is greater than or equal to 150% of the load it is carrying, as a factor of safety. Supporting calculations shall be furnished to verify the minimum capacity requirement is maintained for the duration of the hoisting operation.
4. Dynamic hoisting operations are prohibited when carrying a load with the Potential to Foul. Cranes or other lifting equipment shall remain stationary during lifting. (i.e., no moving picks).
5. For lifting equipment, the manufacturer's capacity charts, including crane, counterweight, maximum boom angle, and boom nomenclature is to be submitted.
6. A schematic rigging diagram must be provided to clearly call out each rigging component from crane hook to the material being hoisted. Copies of catalog or information sheets shall be provided to verify rigging weights and capacities.
7. For built-up rigging devices, the contractor shall submit the following:
 - i. Details of the device, calling out material types, sizes, connections and other properties.
 - ii. Load test certification documents and/or design computations bearing the seal and signature of a Professional Engineer. Load test shall be performed in the configuration of its intended use as part of the subject demolition procedure.
 - iii. Copies of the latest inspection reports of the rigging device. The device shall be inspected within one (1) calendar year of the proposed date for use.
8. A detail shall be provided showing the crane outrigger setup, including dimensions from adjacent slopes or facilities. The detail shall indicate requirements for bearing surface preparation, including material requirements and compaction efforts. As a minimum, outriggers and/or tracks shall bear on mats, positioned on level material with adequate bearing capacity.
9. A complete written narrative that describes the sequence of events, indicating the order of lifts and any repositioning or re-hitching of the crane(s).

IV. DEMOLITION PROCEDURE

- A. The Agency or its Contractor shall submit a detailed procedure for a controlled demolition of any structure on, over, or adjacent to the ROW. The controlled demolition procedure must be approved by the Engineer prior to beginning work on the project.
- B. Existing Condition of structure being demolished:
 1. The Contractor shall submit as-built plans for the structure(s) being demolished.
 2. If as-built plans are unavailable, the Contractor shall perform an investigation of the structure, including any foundations, substructures, etc. The field measurements are to be made under the supervision of the Professional Engineer submitting the demolition procedure. Findings shall be submitted as part of the demolition means and methods submittal for review by the Engineer.
 3. Any proposed method for temporary stabilization of the structure during the demolition shall be based on the existing plans or investigative findings, and submitted as part of the demolition means and methods for review by the Engineer.

- C. Demolition work plans shall include a schematic plan depicting the proposed locations of the following, at various stages of the demolition:
1. All cranes and equipment, calling out the operating radii.
 2. All proposed access and staging locations with all dimensions referenced from the center line of the nearest track.
 3. Proposed locations for stockpiling material or locations for truck loading.
 4. The location, with relevant dimensions, of all tracks, other railroad facilities; wires, poles, adjacent structures, or buried utilities that could be affected, showing that the proposed lifts are clear of these obstructions.
 5. Note that no crane or equipment may be set on the CSXT rails or track structure and no material may be dropped on CSXT property.
- D. Demolition submittal shall also include the following information:
1. All hoisting details, as dictated by Section III of this document.
 2. A time schedule for each of the various stages must be shown as well as a schedule for the entire lifting procedure. The proposed time frames for all critical subtasks (i.e., torch/saw cutting various portions of the superstructure or substructure, dismantling splices, installing temporary bracing, etc.) shall be furnished so that the potential impact(s) to CSXT operations may be assessed and eliminated or minimized.
 3. The names and experience of the key Contractor personnel involved in the operation shall be included in the Contractor's means and methods submission.
 4. Design and supporting calculations shall be prepared, signed, and sealed by the Professional Engineer for items including the temporary support of components or intermediate stages shall be submitted for review. A guardrail will be required to be installed in a track in the proximity of temporary bents or shoring towers, when located within twelve feet (12'-0") from the centerline of the track. The guardrail will be installed by CSXT forces, at the expense of the Agency or its contractor.
- E. Girders or girder systems shall be stable at all times during demolition. Temporary bracing shall be provided at the piers, abutments, or other locations to resist overturning and/or buckling of the member(s). The agency shall submit a design and details of the proposed temporary bracing system, for review by the Engineer. Lateral wind forces for the temporary conditions shall be considered in accordance with AREMA, Chapter 8, Section 28.6.2. The minimum lateral wind pressure shall be fifteen pounds per square foot (15 psf).
- F. Existing, obsolete, bridge piers shall be removed to a minimum of three feet (3'-0") below the finished grade, final ditch line invert, or as directed by the Engineer.
- G. A minimum quantity of twenty five (25) tons of CSXT approved granite track ballast may be required to be furnished and stockpiled on site by the Contractor, or as directed by the Engineer.
- H. The use of acetylene gas is prohibited for use on or over CSXT property. Torch cutting shall be performed utilizing other materials such as propane.
- I. CSXT's tracks, signals, structures, and other facilities shall be protected from damage during demolition of existing structure or replacement of deck slab.
- J. Demolition Debris Shield
1. On-track or ground-level debris shields (such as crane mats) are prohibited for use by CSXT.
 2. Demolition Debris Shield shall be installed prior to the demolition of the bridge deck or other relevant portions of the structure. The demolition debris shield shall be erected from the underside of the bridge over the track area to catch all falling debris. The debris shield shall not be the primary means of debris containment.
 - i. The demolition debris shield design and supporting calculations, all signed/sealed by a Professional Engineer, shall be submitted for review and acceptance.
 - ii. The demolition debris shield shall have a minimum design load of 50 pounds per square foot (50 psf) plus the weight of the equipment, debris, personnel, and all other loads.

- iii. The Contractor shall verify the maximum particle size and quantity of the demolition debris generated during the procedure does not exceed the shield design loads. Shield design shall account for loads induced by particle impact; however the demolition procedure shall be such that impact forces are minimized. The debris shield shall not be the primary means of debris containment.
- iv. The Contractor shall include installation/removal means and methods for the demolition debris shield as part of the proposed Controlled Demolition procedure submission.
- v. The demolition debris shield shall provide twenty three feet (23'-0") minimum vertical clearance, or maintain the existing vertical clearance if the existing clearance is less than twenty three feet (23'-0").
- vi. Horizontal clearance to the centerline of the track should not be reduced unless approved by the Engineer.
- vii. The Contractor shall clean the demolition debris shield daily or more frequently as dictated either by the approved design parameters or as directed by the Engineer.

K. Vertical Demolition Debris Shield

- 1. This type of shield may be required for substructure removals in close proximity to CSXT track and other facilities, as determined by the Engineer.
- 2. The Agency or its Contractor shall submit detailed plans with detailed calculations, prepared, signed, and sealed by a Professional Engineer, of the protection shield.

V. ERECTION PROCEDURE

- A. The Agency or its Contractor shall submit a detailed procedure for erection of a structure with Potential to Foul. The erection procedure must be approved by the Engineer prior to beginning work on the project.
- B. Erection work plans shall include a schematic plan depicting the following, at all stages of the construction:
 - 1. All proposed locations of all cranes and equipment, calling out the operating radii.
 - 2. All proposed access and staging locations with all dimensions referenced from the center line of the nearest track.
 - 3. All proposed locations for stockpiling material or locations for truck loading.
 - 4. The location, with relevant dimensions, of all tracks, other railroad facilities; wires, poles, adjacent structures, or buried utilities that could be affected, showing that the proposed lifts are clear of these obstructions.
- C. No crane or equipment may be set on the CSXT rails or track structure and no material may be dropped on CSXT property.
- D. For erection of a structure over the tracks, the following information shall be submitted for review and acceptance by the Engineer, at least thirty (30) days prior to erection:
 - 1. As-built beam seat elevations – field surveyed upon completion of pier/abutment construction.
 - 2. Current Top of Rail (TOR) elevations – field measured at the time of as-built elevation collection.
 - 3. Computations verifying the anticipated minimum vertical clearance in the final condition which accounts for all deflection and camber, based upon the current TOR and as-built beam seat elevations. The anticipated minimum vertical clearance shall be greater than or equal to that which is indicated by the approved plans. Vertical clearance (see definitions) is measured from TOR to the lowest point on the overhead structure at any point within six feet (6'-0") from centerline of the track. Calculations shall be signed and sealed by a Professional Engineer.
- E. Girders or girder systems shall be stable at all times during erection. No crane may unhook prior to stabilizing the beam or girder.
 - 1. Lateral wind forces for the temporary conditions shall be considered in accordance with AREMA, Chapter 8, Section 28.6.2. The minimum lateral wind pressure shall be fifteen pounds per square foot (15 psf).
 - 2. Temporary bracing shall be provided at the piers, abutments, or other locations to resist overturning and/or buckling of the member(s). The agency shall submit a design and details of the proposed temporary bracing system, for review by the Engineer.
 - 3. Temporary bracing shall not be removed until sufficient lateral bracing or diaphragm members have been installed to establish a stable condition. Supporting calculations, furnished by the Professional Engineer, shall confirm the stable condition.
- F. Erection procedure submissions shall also include the following information:
 - 1. All hoisting details, as dictated by Section III of this document.
 - 2. A time schedule for each of the various stages must be shown as well as a schedule for the entire lifting procedure.

The proposed time frames for all critical subtasks (i.e., performing aerial splices, installing temporary bracing, installation of diaphragm members, etc.) shall be furnished so that the potential impact(s) to CSXT operations may be assessed and eliminated or minimized.

3. The names and experience of the key Contractor personnel involved in the operation shall be included in the Contractor's means and methods submission.
4. A guardrail will be required to be installed in a track in the proximity of temporary bents or shoring towers, when located within twelve feet (12'-0") from the centerline of the track. The guardrail will be installed by CSXT forces, at the expense of the Agency or its Contractor.
5. Design and supporting calculations prepared by the Professional Engineer for items including the temporary support of components or intermediate stages shall be submitted for review.

VI. TEMPORARY EXCAVATION AND SHORING

- A. The Agency or its Contractor shall submit a detailed design and procedure for the installation of a sheeting/shoring system adjacent to the tracks. Shoring protection shall be provided when excavating with Potential to Foul, or as otherwise determined by CSXT. Shoring shall be provided in accordance with the AREMA, except as noted below.
- B. Shoring may not be required if all of the following conditions are satisfied:
 1. The excavation does not encroach within the Theoretical Live Load Influence Zone. Please refer to Figure 1.
 2. The track structure is situated on level ground, or in a cut section, and on stable soil.
 3. The excavation does not adversely impact the stability of a CSXT facility (i.e., signal bungalow, drainage facility, undergrade bridge, building, etc), or the stability of any structure on, over, or adjacent to CSXT property with potential to foul.
 4. Shoring is not required by any governing federal, state, local or other construction code.
- C. Shoring is required when excavating the toe of an embankment. Excavation of any embankment which supports an active CSXT track structure without shoring will not be permitted.
- D. Trench boxes are not an acceptable means of shoring. Trench boxes are prohibited for use on CSXT property or within the Theoretical Railroad Live Load Influence Zone.
- E. Shoring shall be a cofferdam-type, which completely encloses the excavation. However, where justified by site or work conditions, partial cofferdams with open sides away from the track may be permissible, as determined by the Engineer.
- F. Cofferdams shall be constructed using interlocking steel sheet piles, or when approved by the Engineer, steel soldier piles with timber lagging. Wales and struts shall be included when dictated by the design.
- G. The use of tiebacks can be permissible for temporary shoring systems, when conditions warrant. Tiebacks shall have a minimum clear cover of 6'-0", measured from the bottom of the rail. Upon completion of the work, tiebacks shall be grouted, cut off, and remain in place.
- H. All shoring systems on, or adjacent to CSXT right-of-way, shall be equipped with railings or other fall protection, compliant with the governing federal, state or local requirements. Area around pits shall be graded to eliminate all potential tripping hazards.
- I. Interlocking steel sheet piles shall be used for shoring systems qualifying one or more of the following conditions:
 1. Within 18'-0" of the nearest track centerline
 2. Within the live load influence zone
 3. Within slopes supporting the track structure
 4. As otherwise deemed necessary by the Engineer.
- J. Sheet piles qualifying for one or more of the requirements listed in Section VI.I (above) of this document shall not be removed. Sheet piles shall be left in place and cut off a minimum of 3'-0" below the finished grade, the ditch line invert, or as otherwise directed by the Engineer. The ground shall be backfilled and compacted immediately after sheet pile is

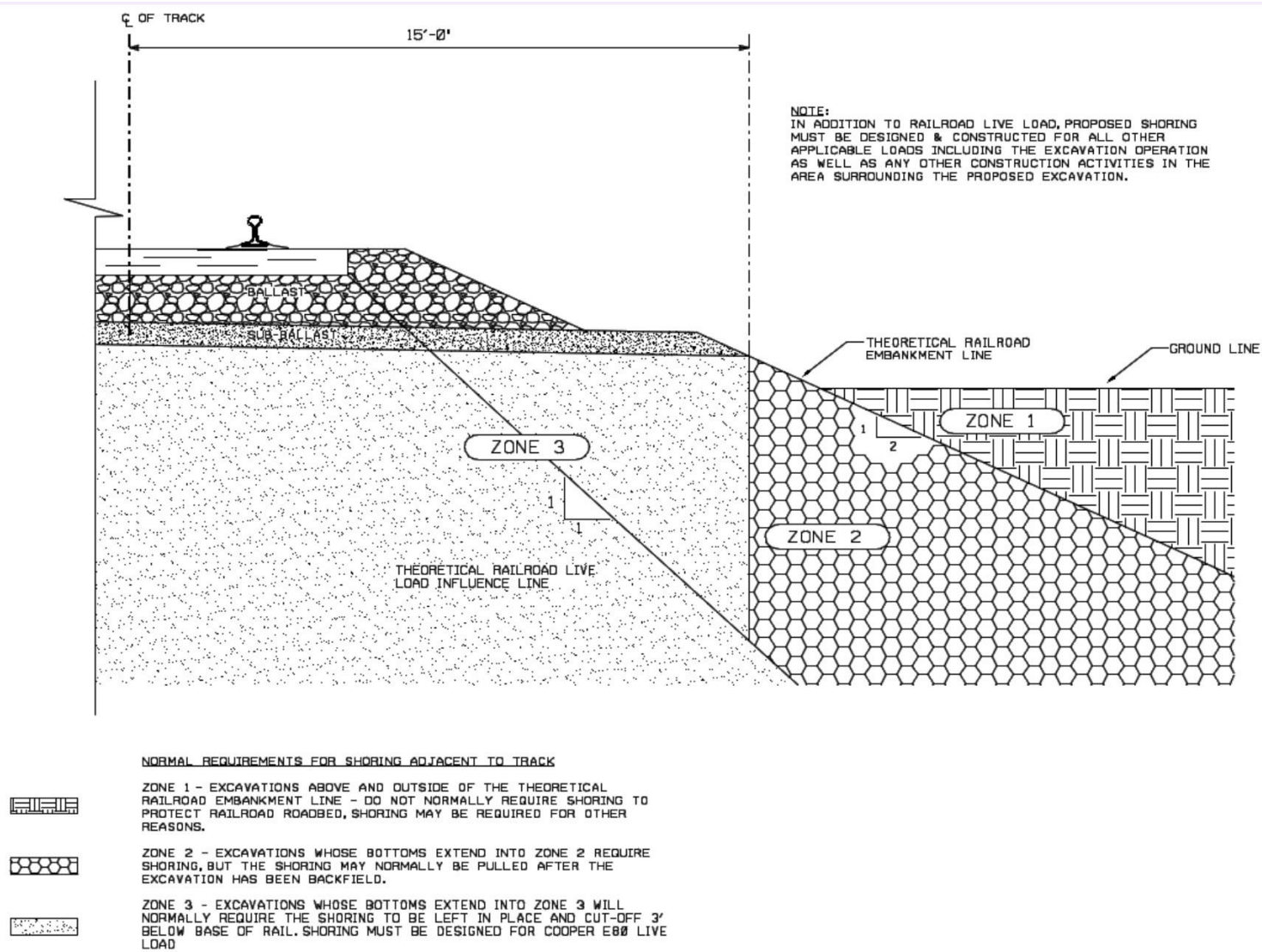
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- K. The following design considerations shall be considered when preparing the shoring design package:
1. Shoring shall be designed to resist a vertical live load surcharge of 1,880 lbs. per square foot, in addition to active earth pressure. The surcharge shall be assumed to act on a continuous strip, eight feet six inches (8'-6") wide.
Lateral pressures due to surcharge shall be computed using the strip load formula shown in *AREMA Manual for Railway Engineering*, Chapter 8, Part 20.
 2. Allowable stresses in materials shall be in accordance with AREMA Chapter 7, 8, and 15.3.
 3. A minimum horizontal clearance of ten feet (10'-0") from centerline of the track to face of nearest point of shoring shall be maintained, provided a twelve feet (12'-0") roadbed is maintained with a temporary walkway and handrail system.
 4. For temporary shoring systems with Potential to Foul, piles shall be plumb under full dead load. Maximum deflection at the top of wall, under full live load, shall be as follows:
 - i. One-half (1/2) inch for walls within twelve feet (12'-0") of track centerline (Measured from centerline of the nearest track to the nearest point of the supporting structure).
 - ii. One (1) inch for walls located greater than twelve feet (12'-0") from track centerline
- L. Shoring work plans shall be submitted in accordance with Section II of this document, as well as the following additional requirements:
1. The work plan shall include detailed drawings of the shoring systems calling out the sizes of all structural members, details of all connections. Both plan and elevation drawings shall be provided, calling out dimensions from the face of shoring relative to the nearest track centerline. The elevation drawing shall also show the height of shoring, and track elevation in relation to bottom of excavation.
 2. Full design calculations for the shoring system shall be furnished.
 3. A procedure for cutting off the sheet pile, backfilling and restoring the embankment.

VII. TRACK MONITORING

- A. When work being performed has the potential to disrupt the track structure, a work plan must be submitted detailing a track monitoring program which will serve to monitor and detect both horizontal and vertical movement of the CSXT track and roadbed.
- B. The program shall specify the survey locations, the distance between the location points, and frequency of monitoring before, during, and after construction. CSXT reserves to the right to modify the survey locations and monitoring frequency as necessary during the project.
- C. The survey data shall be collected in accordance with the approved frequency and immediately furnished to the Engineer for analysis.
- D. If any movement has occurred as determined by the Engineer, CSXT will be immediately notified. CSXT, at its sole discretion, shall have the right to immediately require all contractor operations to be ceased, have the excavated area immediately backfilled and/or determine what corrective action is required. Any corrective action required by CSXT or performed by CSXT including the monitoring of corrective action of the contractor will be at project expense.

FIGURE 1: Theoretical Live Load Influence Zone





APPENDIX C

GEOTECHNICAL REPORT

QUANTICO STATION REDESIGN

Note: The requirements of this Appendix are applicable to the Contractor's "Means and Methods" for planning, submissions, approvals and execution of the work.

Measurement and Payment for items as required will be included in other pay items. See PAY ITEM DESCRIPTION & ESTIMATED QUANTITIY SUMMARY of the plans.

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APPENDIX C

GEOTECHNICAL REPORT

QUANTICO STATION REDESIGN

Note: The Geotechnical Report is provided for Information Only. The Report was prepared solely for the use of VRE/DRPT in establishing design controls for the project.

The Report is made available to bidders in order that they may have access to design data identical to that which is possessed by VRE/DRPT and is not intended as a substitute for personal investigation, interpretation and judgement by the bidders.

March 29, 2016

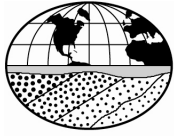
Geotechnical Engineering Report

**Quantico Station Redesign
Arkendale-Powells Creek
Third Track Project
501 Railroad Avenue
Prince William County, Virginia**



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March 29, 2016

Revision: 0

Mr. Ronald C. Briggs, PE
STV, Inc.
10800 Midlothian Turnpike, Suite 302
Richmond, VA 23235

**Subject: Geotechnical Engineering Report, Quantico Station
Redesign, Arkendale-Powells Creek Third Track Project,
501 Railroad Avenue, Prince William County, Virginia
(GeoConcepts Project No. 15184)**

Dear Mr. Briggs:

GeoConcepts Engineering, Inc. (GeoConcepts) is pleased to present the following geotechnical engineering report prepared for Quantico Station Redesign in Prince William County, Virginia.

We appreciate the opportunity to serve as your geotechnical consultant on this project. Please do not hesitate to contact me if you have any questions or want to meet to discuss the findings and recommendations contained in the report.

Sincerely,

GEOCONCEPTS ENGINEERING, INC.

Sushant Upadhyaya, PhD, PE, PMP
Senior Engineer
supadhyaya@geoconcepts-eng.com

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Figure 1: Site Vicinity Map

Appendix A: Subsurface Investigation
Appendix B: Soil Laboratory Test Results
Appendix C: Engineering Calculations

1.0 Scope of Services

This geotechnical engineering report presents the results of the field investigation, soil laboratory testing, and engineering analysis of the geotechnical data. This report specifically addresses the following:

- An evaluation of subsurface conditions within the area of the proposed pedestrian bridge, proposed platform and platform extension, including a seismic site classification per the International Building Code (IBC) and American Association of Highway and Transportation Officials (AASHTO), and metal corrosion and concrete attack potential of on-site soils.
- Foundation subgrade recommendations for support of the proposed pedestrian bridge and station platforms.
- Earthwork recommendations for construction of embankment fills, including an assessment of on-site soils to be excavated for re-use as new compacted fill.
- Temporary construction dewatering recommendations.

Services not specifically identified in the contract for this project are not included in the scope of services.

2.0 Site Description and Proposed Construction

The project site is located at 501 Railroad Avenue in Quantico, Prince William County, Virginia. A site vicinity map is presented as Figure 1 at the end of this report. The site is currently developed with a railroad consisting of two tracks. The eastern side of the railroad tracks is occupied by a one-story train station building at the North and a parking lot at the South. A canopy waiting point and parking spaces are located on the west side of the railroad tracks. The elevation at the site ranges from approximately elevation EL 30 to EL 33, sloping downward towards the south.

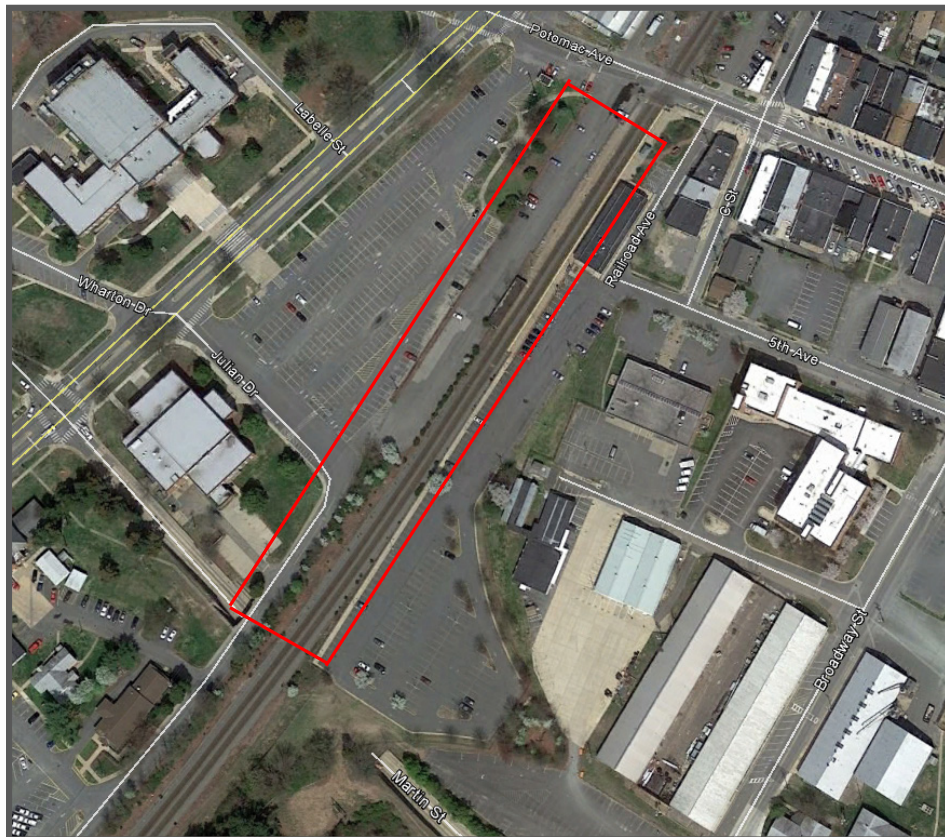


Image Google Earth 2016

Based on plans provided to us, the proposed construction consists of extending the existing 12 feet wide platform on the east side of the railroad tracks by about 490 feet, and constructing a new 12 feet wide, 907 feet long platform on the west side of the existing railroad tracks, as well as construction of a pedestrian bridge. We understand that the proposed plans include a bottom of slab elevation at EL 31 for the station platforms, and bottom of foundations at EL 30 for the pedestrian bridge. The maximum column load is about 90 kips for the proposed pedestrian bridge.

3.0 Subsurface Conditions

Subsurface conditions were investigated by drilling a total of five test borings, two borings in the platform areas and three borings in the proposed pedestrian bridge area. Test boring logs and a boring location plan are presented in Appendix A of this report.

A previous geotechnical engineering report dated April 23, 2010 was prepared for this project by GeoConcepts Engineering. The report was conducted for a different development plan, with one test boring (B-27) in the proposed west platform area.

In addition, a memorandum dated March 16, 2015 was prepared by RK&K subsurface studies, of which one test boring (T-035) is located in the proposed west platform area. One test boring (T-036) is located just north of the proposed pedestrian bridge. Although the geotechnical recommendations presented in that report do not apply to this project, the subsurface information from that study has been reviewed as a part of this project. Test boring data by others is assumed to be complete and accurate. We do not assume any responsibility for the completeness and accuracy of data obtained from others without our supervision.

3.1 Geology

The site is located within the Coastal Plain Physiographic Province of Virginia. The Coastal Plain consists of a seaward thickening wedge of unconsolidated to semi-consolidated sedimentary deposits from the Cretaceous Geologic Period to the Holocene Geologic Epoch. These deposits represent marginal-marine to marine sediments consisting of interbedded sands and clays. The Coastal Plain is bordered to the east by the Atlantic Ocean and to the west by the Piedmont Physiographic Province. The dividing line between the Coastal Plain and the Piedmont is locally referred to as the "Fall Line". This name comes from the waterfalls that form as a result of the differential erosion that occurs as streams cross the Piedmont/Coastal Plain contact.

Specifically, according to local geologic maps, the site is mapped in the Terrace Deposits of the Potomac River, from the Pleistocene and Holocene ages. Based on our subsurface investigation, the sediments and strata correspond favorably to the geologic publications.

3.2 Stratification

The subsurface materials encountered have been stratified for purposes of our discussions herein. These stratum designations do not imply that the materials encountered are continuous across the site. Stratum designations have been established to characterize similar subsurface conditions based on material gradations and parent geology. The generalized subsurface materials encountered in the test borings completed at the site have been assigned to the following strata:

Stratum A (Existing Fill)	loose to very dense or firm to very stiff, clayey sand with gravel, lean clay with sand, FILL, moist, black, gray and green
Stratum B1 (Terrace Deposits)	soft to very stiff, FAT CLAY (CH), LEAN CLAY (CL), and ELASTIC SILT (MH), with various amounts of sand, moist, gray and orange

Stratum B2
(Terrace Deposits)

loose to very dense, clayey SAND (SC), silty SAND (SM), and POORLY GRADED SAND with clay (SP-SC), moist to wet, gray, orange, and brown

The two letter designations included in the strata descriptions presented above and on the test boring logs represent the Unified Soil Classification System (USCS) group symbol and group name for the samples based on laboratory testing per ASTM D-2487 and visual classifications per ASTM D-2488. It should be noted that visual classifications per ASTM D-2488 may not match classifications determined by laboratory testing per ASTM D-2487.

3.3 Groundwater

Groundwater level observations were made in the field during drilling. A summary of the water level readings rounded off to the nearest 0.5 feet elevation is presented in the Table 3.3-1.

Table 3.3-1: Groundwater Level Readings

Location	Test Boring No.	Depth to Groundwater (ft)	Groundwater Elevation (ft)	Proposed Bottom of Slab/Footing Elevation (ft)
East Platform	B-1	20.5	EL 9.5	EL 29 - 31±
West Platform	B-2	13.5	EL 18.5	
Pedestrian bridge	B-3	11.5	EL 20.5	EL 30±
	B-4	8.5	EL 23.5	
	B-5	13.5	EL 19.0	

As shown in Table 3.3-1, groundwater was encountered at depths of about 8.5 to 20.5 feet below the existing ground surface, or at about EL 9.5 to EL 23.5. However, it is recommended that a groundwater level at EL 25 be used for design, which is approximately two feet above the highest groundwater level observed in the recently completed test borings in order to take seasonal fluctuations into consideration.

The groundwater observations presented herein are considered to be an indication of the groundwater levels at the dates and times indicated. Where more impervious silt and clay soils of Stratum B1 are encountered, the amount of water seepage into the borings is limited, and it is generally not possible to establish the location of the groundwater table through short term water level observations. Accordingly, the groundwater information presented herein should be used with caution. Also, fluctuations in groundwater levels should be expected with seasons of the year, construction activity, changes to surface grades, precipitation, or other similar factors.

3.4 Soil Laboratory Test Results

Selected soil samples obtained from the field investigation were tested for grain size distribution, Atterberg limits, corrosion and concrete attack characteristics, and natural moisture content. A summary of soil laboratory test results is presented in the following sections and individual soil laboratory test reports are presented in Appendix B.

3.4.1 Classification Test Results

A total of five samples were submitted for classification testing, as summarized in the table below. Results of additional natural moisture content tests are presented on the test boring logs in Appendix A.

Table 3.4.1-1: Summary of Laboratory Test Results

Test Boring No.	Depth (ft)	Sample Type	Stratum	Description of Soil Specimen	Sieve Results		Atterberg Limits			Natural Moisture Content (%)
					Percent Retained #4 Sieve	Percent Passing #200 Sieve	LL	PL	PI	
B-1	33.5-35.0	Split Spoon	B2	Silty SAND (SM)	3.6	40.6	52	34	18	27.3
B-2	0.7-2.7	Split Spoon	A	LEAN CLAY with sand (CL)	0.3	83.6	34	18	16	21.5
B-3	4.6-6.6	Split Spoon	B1	LEAN CLAY with sand (CL)	0.0	85.2	48	21	27	24.1
B-4	6.6-8.6	Split Spoon	B2	Clayey SAND (SC)	0.5	23.8	33	20	13	16.2
B-5	13.5-15.0	Split Spoon	B1	Sandy LEAN CLAY (CL)	0.0	54.7	36	18	18	18.9

Notes:

1. Soil tests are in accordance with applicable ASTM standards
2. Soil classification symbols are in accordance with Unified Soil Classification System
3. Key to abbreviations: LL = liquid limit; PL = plastic limit; PI = plasticity index

3.4.2 Metal Corrosion Test Results

In addition to standard geotechnical soil laboratory testing, one soil sample was submitted to an analytical laboratory for metal corrosion and concrete attack testing. Corrosion testing consisted of analysis for moisture content (ASTM D-2216), pH (CA643), resistivity (ASTM G87), sulfides (EPA 376.2), and reduction-oxidation potential (Electrode). The results of these tests are presented below:

Table 3.4.2-1: Metal Corrosion Test Results

Test Boring No.	Sample Depth (ft)	Moisture Content (%)	pH	Resistivity (ohm – cm)	Sulfides (ppm)	Red-ox Potential (mV)	Point Total
B-4	4.0-6.0	23	5.1	6,900	<1.2	+385	3

For each test presented above, points are assigned based on the range of the test results. If the total points from the five tests completed for a particular sample are 10 or more, the soil is considered to be corrosive. The methods described herein are based on information from the American Water Works Association (AWWA). Using the methods described by AWWA, the point total for the sample tested is equal to 3. Accordingly, the site soils are considered non-corrosive.

3.4.3 Concrete Attack Test Results

Sulfate (CA Test 417) tests were performed on a selected soil sample to determine the severity of sulfate attack on concrete structures. The results of sulfate testing are presented in the table below.

Table 3.4.3-1: Metal Corrosion Test Results

Test Boring No.	Sample Depth (ft)	Sulfate Concentration (ppm)
B-4	4.0-6.0	25

Based on correlations between sulfate concentrations and severity of sulfate attack as presented in American Concrete Institute (ACI) 318, the above sulfate concentrations are considered to pose a negligible threat of sulfate attack on concrete.

3.5 Seismic Site Classification

We have evaluated the Soil Profile Type and Site Coefficient for this project according to the 2012 International Building Code (IBC) and the 2009 AASHTO LRFD Bridge Design Specification. Based on the results of the current and previous subsurface investigation and our knowledge of local geologic conditions, the site soils have been assigned to a site class D.

The site coefficients and adjusted Maximum Considered Earthquake (MCE) spectral response acceleration parameters were obtained from the United States Geological Survey (USGS) website and are presented in Tables 3.5-1 through 3.5-2.

Table 3.5-1: Site Coefficients and Adjusted MCE Spectral Response Acceleration per IBC

Mapped Spectral Accelerations for Site Class D and 5% Damping (Step 1)	Site Coefficients to Modify Accelerations Based on Site Classification D (Step 2)
$S_s = 0.127 \text{ g}$	$F_a = 1.6$
$S_1 = 0.053 \text{ g}$	$F_v = 2.4$
MCE Spectral Response Accelerations (Step 3)	Design Spectral Response Accelerations (Step 4)
$S_{MS} = 0.204 \text{ g}$	$S_{DS} = 0.136 \text{ g}$
$S_{M1} = 0.126 \text{ g}$	$S_{D1} = 0.084 \text{ g}$

Table 3.5-2: Site Coefficients and Adjusted MCE Spectral Response Acceleration per AASHTO

Mapped Spectral Accelerations for Site Class D (Step 1)	Site Coefficients to Modify Accelerations Based on Site Classification D (Step 2)	Design Spectral Response Accelerations (Step 3)
$S_s = 0.091 \text{ g}$	$F_a = 1.6$	$S_{DS} = 0.1456 \text{ g}$
$S_1 = 0.031 \text{ g}$	$F_v = 2.4$	$S_{D1} = 0.074 \text{ g}$

4.0 Engineering Analysis

Recommendations regarding the pedestrian bridge foundations, platform subgrades, earthwork, and temporary construction dewatering are presented herein.

4.1 Foundations

The pedestrian bridge at Quantico station will be constructed just north of the platforms. The maximum axial column load is about 90 kips. The pedestrian bridge may be supported on mat foundation or spread footing with a bottom elevation (EL) of $30 \pm$. We also understand that canopies are planned for the east and west platforms; however, the locations are not known at the time of writing this report. Table 4.1-1 below presents the foundation bearing strata and elevations. Sections 4.1.1, 4.1.2 presents the foundation recommendations for mat foundation and spread footing respectively. Section 4.1.3 presents the foundation recommendation for the canopy.

Table 4.1-1: Foundation Bearing Strata and Elevation – Pedestrian Bridge

Location	Test Boring No.	Existing Ground Surface Elevation (ft)	Bottom of Footing Elevation (ft)	Bearing Stratum	Remark/ Recommendations
Pedestrian Bridge – West Foundation	B-3	EL 32±	EL 30±	Existing Fill (A)	Undercut to EL 27 and replace with new compacted fill (VDOT 21B)
Pedestrian Bridge – Center Foundation	B-4	EL 32±	EL 30±	Existing Fill (A)	Undercut to EL 27 and Replace with New Compacted Fill (VDOT 21B)
Pedestrian Bridge – East Foundation	B-5	EL 33±	EL 30±	Lean CLAY (CL) – (B1)	--
Canopy – East Platform	B-1	EL 30±	--	Existing Fill (A)	Undercut to EL 29 and Replace with New Compacted Fill (VDOT 21B)
Canopy – Wet Platform	B-2	EL 32±	--	Existing Fill (A)	Undercut to EL 29 and Replace with New Compacted Fill (VDOT 21B)

As presented in Table 4.1-1, the existing fill will not be suitable for direct support of footings. Accordingly, we recommend undercutting the existing fill up to 5 feet, or to natural soils, whichever is less, and backfilled with VDOT No. 21B aggregate. Care should be taken during excavation for mat and spread footings to minimize the amount of disturbed material below the footing grade. All final bearing surfaces should be observed by the QC Engineer to ascertain that foundations are placed on suitable bearing material.

4.1.1 Mat Foundation - Pedestrian Bridge

A mat foundation system is recommended for support of the proposed pedestrian bridge. The mat foundation is approximately 3 feet thick in the middle and 4.6 feet thick at the perimeter. Table 4.1.1-1 presents the bearing pressure and settlement at the mat foundation locations. Calculations are presented in Appendix C. Hydrostatic uplift pressures are not expected to be required in the mat design based on the design groundwater elevation of (EL) 25.

Table 4.1.1-1: Mat Foundation Recommendations – Pedestrian Bridge

Location	Bottom of Footing Elevation (ft) ¹	Net Allowable Bearing Capacity (ksf) ²	Footing Size (ft)	Settlement (inch)				Remark
				Total	Immediate	Consolidation	Post-Construction	
Pedestrian Bridge – West Foundation	EL 30±	2.5	14 X 38	2.9	2.2	0.7	<0.5	1 month waiting period.
Pedestrian Bridge – Center Foundation	EL 30±	2.5	16 X 38	3.0	2.3	0.7	<0.5	

Location	Bottom of Footing Elevation (ft) ¹	Net Allowable Bearing Capacity (ksf) ²	Footing Size (ft)	Settlement (inch)				Remark
				Total	Immediate	Consolidation	Post-Construction	
Pedestrian Bridge – East Foundation	EL 30±	2.5	22 X 38	3.2	2.5	0.7	<0.5	1 month waiting period.

Notes:

1. See Table 4.1-1 for bearing stratum and recommendations.
2. Factor of Safety of 3 is used to calculate net allowable bearing resistance.

Table 4.1.1-2 presents the values for the modulus of subgrade reaction, k , for a 1 foot square plate for the bearing soils. Caution should be used in determining the proper modulus of subgrade reaction to be input into a computerized solution to determine the thickness of the slab. Specifically, the modulus of subgrade reaction for the specific computer program being used should be based on the actual size of the slab's bearing/reaction area.

Table 4.1.1-2: Modulus of Subgrade

Location	Bearing Material	Modulus Values (pci)
Pedestrian Bridge – West Foundation	New Compacted Fill (VDOT 21B)	200
Pedestrian Bridge – Center Foundation		
Pedestrian Bridge – East Foundation	Lean CLAY (CL) – (B1)	125

Strict quality control should be provided during construction of the mat to ensure that the mat is placed on undisturbed subgrade soils immediately after excavations are complete. The excavation should be performed using equipment that can reach out and cut down to the subgrade without tracking across the subgrade and disturbing the underlying material. A 3 to 4-inch thick concrete work mat should be placed on the freshly excavated subgrade, to allow for installation of reinforcing steel prior to the final mat pour. Excavations should not be performed in inclement weather that causes the excavated subgrade to become disturbed, and excavations should not be left open overnight without placing a concrete work mat on the subgrade. Also, the prepared subgrade must be prevented from freezing if work is performed in the winter months. It is noted that in cases where a concrete work mat has been installed and cold weather conditions exist, provisions should be made to prevent the underlying soil subgrade from freezing and becoming disturbed.

The mat may be placed in sections or in one continuous concrete pour. If the mat is placed in one continuous pour, we recommend that super plasticizers be used in the concrete mix design to decrease the water to cement ratio, which will in turn, reduce the potential for shrinkage cracks in the mat. Cold joints should not be permitted during placement of the mat concrete. If the mat is placed in sections, we recommend that the construction joints be designed so as to ensure that the joints are water tight. We recommend that the mat be placed in a checkerboard fashion so that every other square is placed to minimize shrinkage effects. If internal braces (rakers) are utilized for the support of the earth retention system, box outs within the mat will be required due to penetration of the rakers for the mats. The joints in the mat around the rakers should also be constructed using a water tight seal.

4.1.2 Spread Footing – Pedestrian Bridge

Alternatively, spread footing can be used for the support of pedestrian bridge. Table 4.1.2-1 presents the bearing pressure and settlement for the spread footings. Calculations are presented in Appendix C.

Table 4.1.2-1: Spread Footing Recommendations – Pedestrian Bridge

Location	Bottom of Footing Elevation (ft) ¹	Net Allowable Bearing Capacity (ksf) ²	Footing Size (ft)	Settlement (inch)				Remark
				Total	Immediate	Consolidation	Post-Construction	
Pedestrian Bridge	EL 30±	3.0	6X6	1.3	0.8	0.5	<0.5	1 month waiting period

Notes:

1. See Table 4.1-1 for bearing stratum and recommendations.
2. Factor of Safety of 3 is used to calculate net allowable bearing resistance.

4.1.3 Spread Footing - Canopy

Spread footings can be used for the support of proposed canopy. Firm natural soils or new compacted fill should be encountered at proposed spread footing elevations. Spread footings founded in these materials are considered suitable for support of the proposed canopy, and may be designed with a net allowable bearing capacity of 3.0 ksf.

4.2 General Foundation Recommendations – Spread Footings

Exterior footing subgrades should be located at least 2.0 feet below final exterior grades for frost considerations, except where expansive fat clay or elastic silt soils of Stratum B1 are present at footing subgrades, footings should be lowered to a depth of 5.0 feet below final exterior grade per Prince William County requirements or until the fat clay (CH) or elastic silt (MH) material is no longer present, whichever is less. Interior footings may be placed at normal structural depths where Stratum B1 fat clay (CH) or elastic silt (MH) soils are encountered.

Fill material and compaction requirements are presented in Section 4.4 of this report. Individual column footings and continuous wall footings should be at least 30 inches and 18 inches wide, respectively, for local or punching shear considerations. A maximum slope of one horizontal to one vertical (1H:1V) should be maintained between the bottom edges of adjacent footings.

Footing subgrades should be observed and approved by the Geotechnical Engineer of Record or his/her representative prior to placement of concrete, to ascertain that footings are placed on suitable bearing soils as recommended herein. Footings should be excavated and concrete placed the same day in order to avoid disturbance from water or weather. Disturbance of footing subgrades by exposure to water seepage or weather conditions should be avoided. If encountered, we recommend removing all the existing fill in the footing areas down to natural soils and replace with lean concrete fill as necessary to reach design subgrades. The footings can then be constructed at normal design depths on the lean concrete fill. Any disturbed, frozen, or soft subgrade soils should also be removed prior to placing footing concrete. It may be desirable to place a 3 to 4-inch thick "mud mat" of lean concrete immediately on the approved footing subgrade to avoid softening of the exposed subgrade. Forms may be used if necessary, but less subgrade disturbance is anticipated if excavations are made to the required dimensions and concrete placed against the soil. If footings are formed, the forms should be removed and the excavation backfilled as soon as possible. Water should not be allowed to pond along the outside of footings for long periods of time.

4.3 Platform Slab on Grade

The station platforms will be supported as a slab on grade, with a proposed bottom of slab elevation varying from EL 29 to EL 31. Based on the information provided by the client we understand that the thickness of the platform slab will be about 10 inches. Generally medium dense existing fill will be encountered at this subgrade elevation. These materials are considered suitable for support of the planned platforms; however, we recommend budgeting for undercutting the existing fill to a depth of at least 2 feet and backfilling with new compacted fill. The decision to undercut the existing fill should be based on a thorough proofroll of

the subgrades under the observation of the geotechnical engineer. After undercutting the existing fill and prior to placement of any new compacted fill, the undercut subgrade should be observed during proofrolling by the geotechnical engineer to confirm that the new subgrade is suitable to receive new compacted fill.

In addition, where slab subgrades consist of Stratum B1 fat clay soils, these fat clay soils should be undercut to a depth of at least 2 feet or until the fat clay is no longer present, whichever is less, and backfilled with new compacted fill. Where slab subgrades consist of existing fill, we recommend undercutting the existing fill to a depth of at least 2 feet and backfilling with new compacted fill.

A 6-inch minimum thickness of washed gravel or crushed stone meeting the requirement of AASHTO No. 57 should be placed below floor slabs on grade to serve as a capillary break. An impermeable plastic membrane should be placed on top of the crushed stone layer to assist as a moisture barrier. Special attention should be given to the surface curing of the slab in order to minimize uneven drying of the slab and associated cracking. Underfloor subdrainage is not recommended since groundwater is expected to be below the lower floor level.

In some areas, up to 3 feet of fill may be required to reach platforms subgrade elevations. When supported on new compacted fill, station platforms may be designed based on a modulus of subgrade reaction (K_s) value of 200 pounds per cubic inch (pci). When supported on firm natural soils, station platforms may be designed based on a modulus of subgrade reaction (K_s) value of 125 pounds per cubic inch (pci). The modulus of subgrade reaction is based on a one-foot square plate. Caution should be used in determining the proper modulus of subgrade reaction to be input into a computerized solution to determine the thickness of the slab. Specifically, the modulus of subgrade reaction for the specific computer program being used should be based on the actual size of the slab's bearing/reaction area.

4.4 Earthwork

Fill may be required for site grading. Unsuitable existing fill, soft or loose natural soils, organic material, and rubble should be stripped to approved subgrades as determined by the geotechnical engineer. Asphalt and crushed stone depths presented on the boring logs should not be considered as stripping depths, as asphalt and crushed stone depths may vary widely across the site. The depth of required stripping should be determined prior to construction by the excavation contractor using test pits, probes, or other means that the contractor wishes to employ, and this determination should be the responsibility of the excavation contractor. All subgrades should be proofrolled with a minimum 20 ton, loaded dump truck or suitable rubber tire construction equipment approved by the geotechnical engineer, prior to the placement of new fill.

Fill material should be placed in lifts not exceeding 8 inches loose thickness, with fill materials compacted by hand operated tampers or light compaction equipment placed in maximum 4-inch thick loose lifts. Fill should be compacted at $\pm 2\%$ of the optimum moisture content to at least 95 percent of the maximum dry density per ASTM D-698.

Off Site Borrow Materials shall comply with Section 022216 of the Arkendale to Powell's Creek Third Track Project Specifications. Materials used for compacted fill should consist of soils classifying SC, SM, SP, SW, GC, GM, GP, or GW per ASTM D-2487, having a maximum particle size of three inches (as determined by current ASTM Designation D 422); a plasticity index between 0 and 10 (as determined by current ASTM Designation D 422). It is expected that the soils excavated at the site will generally not be suitable for re-use as fill based on classification. In addition, the Stratum A existing fill may not be suitable for re-use as new compacted fill due to deleterious man-made materials in the fill. Also, drying of excavated soils by spreading and aerating may be necessary to obtain proper compaction. This may not be practical during the wet period of the year. Accordingly, earthwork operations should be planned for early Spring through late Fall, when drier weather conditions can be expected. Individual borrow areas, both from on-site and off-site sources, should be sampled and tested to verify classification of materials prior to their use as fill.

Fill materials should not be placed on frozen or frost-heaved soils, and/or soils that have been recently subjected to precipitation. All frozen or frost-heaved soils should be removed prior to continuation of fill operations. Borrow fill materials should not contain frozen materials at the time of placement.

Compaction equipment that is compatible with the soil type used for fill should be selected. Theoretically, any equipment type can be used as long as the required density is achieved; however, sheepfoot roller equipment are best suited for fine-grained soils and vibratory smooth drum rollers are best suited for granular soils. Ideally, a smooth drum roller should be used for sealing the surface soils at the end of the day or prior to upcoming rain events. In addition, compaction equipment used adjacent to walls below grade should be selected so as to not impose undesirable surcharge on walls. All areas receiving fill should be graded to facilitate positive drainage of any water associated with precipitation and surface run-off.

For utility excavation backfill, we recommend that open graded stone be used to backfill the pipe trench to the spring line of the pipe. Backfill should be compacted in lifts not exceeding 6 inches loose thickness, to at least 95 percent of the maximum dry density per ASTM D-698. Hand operated compaction equipment should be used until the backfill has reached a level 1 foot above the top of the pipe to prevent damaging the pipe. Also, backfill material within 2 feet of the top of the pipe should not contain gravel greater than 1-inch in diameter.

After completion of compacted fill operations, construction of foundation/slab elements should begin immediately, or the finished subgrade should be protected from exposure to inclement weather conditions. Exposure to precipitation and freeze/thaw cycles will cause the finished subgrade to soften and become excessively disturbed. If development plans require that finished subgrades remain exposed to weather conditions after completion of fill operations, additional fill should be placed above finished grades to protect the newly placed fill. Alternatively, a budget should be established for reworking of the upper 1 to 2 feet of previously placed compacted fill.

4.5 Temporary Construction Dewatering

Groundwater was encountered at depths of about 8.5 to 20.5 feet below the existing ground surface, or at about EL 9 to EL 23.5. Based on the groundwater data, we recommend that the contractor be prepared to provide temporary dewatering during construction if groundwater is present during excavations for foundations. We recommend that the dewatering consist of both an aggressive system of individual sumps and pumps during excavation. To help maintain bottom stability of excavations, groundwater levels should be drawn-down a minimum of 3 feet below the lowest portion of the excavation.

Due to the imbedded nature of the sands and clays of the Potomac Group, seeps and/or springs may be encountered during excavations. The volume of water generated by seeps or springs, if present, can vary significantly.

It is critical that as soon as water seepage is observed, the contractor should excavate surface trenches from the observed water seepage to a sump pit and sump pump. If the water is allowed to saturate subgrades, softening of the subgrade will occur very quickly and extra costs will be incurred. However, if the contractor can channel the water to a sump pit and keep the majority of the subgrade from getting saturated, extra costs due to water softening should be significantly reduced. The temporary dewatering system should remain in place until the foundations/slabs are installed.

5.0 General Limitations

Recommendations contained in this report are based upon the data obtained from the relatively limited number of test borings. This report does not reflect conditions that may occur between the points investigated, or between sampling intervals in test borings. The nature and extent of variations between test borings and sampling intervals may not become evident until the course of construction. Therefore, it is essential that on-site observations of subgrade conditions be performed during the construction period to determine if re-evaluation of the recommendations in this report must be made. It is critical to the

successful completion of this project that GeoConcepts be retained during construction to observe the implementation of the recommendations provided herein.

This report has been prepared to aid in the evaluation of the site and to assist your office and the design professionals in the design of this project. It is intended for use with regard to the specific project as described herein. Changes in proposed construction, grading plans, structural loads, etc. should be brought to our attention so that we may determine any effect on the recommendations presented herein.

An allowance should be established for additional costs that may be required for foundation and earthwork construction as recommended in this report. Additional costs may be incurred for various reasons including wet fill materials, soft subgrade conditions, unexpected groundwater problems, etc.

This report should be made available to bidders prior to submitting their proposals to supply them with facts relative to the subsurface conditions revealed by our investigation and the results of analyses and studies that have been performed for this project. In addition, this report should be given to the successful contractor and subcontractors for their information only.

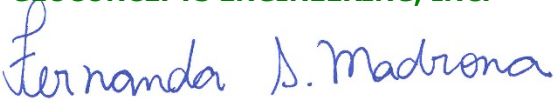
We recommend the project specifications contain the following statement: "A geotechnical engineering report has been prepared for this project by GeoConcepts Engineering, Inc. This report is for informational purposes only and should not be considered part of the contract documents. The opinions expressed in this report are those of the geotechnical engineer and represent their interpretation of the subsoil conditions, tests and results of analyses that they performed. Should the data contained in this report not be adequate for the contractor's purposes, the contractor may make their own investigations, tests and analyses prior to bidding."

This report was prepared in accordance with generally accepted geotechnical engineering practices. No warranties, expressed or implied, are made as to the professional services included in this report.

We appreciate the opportunity to be of service for this project. Please contact the undersigned if you require clarification of any aspect of this report.

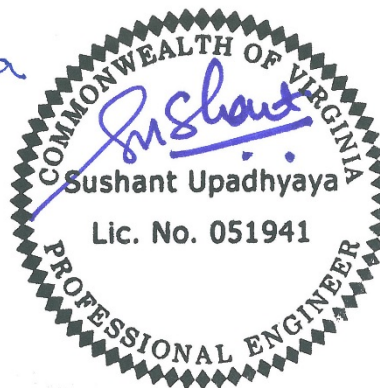
Sincerely,

GEOCONCEPTS ENGINEERING, INC.



Fernanda Madrona, EIT
Senior Staff Engineer

Sushant Upadhyaya, PhD, PE, PMP
Senior Engineer



FM/PEB/SU/clm

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**GeoConcepts
Engineering, Inc.**

19955 Highland Vista Dr., Suite 170 (703) 726-8030
Ashburn, Virginia 20147 (703) 726-8032 fax

ARKENDALE TO POWELLS CREEK THIRD TRACK PROJECT
PRINCE WILLIAM COUNTY, QUANTICO, VIRGINIA

SITE VICINITY MAP

Scale:
N.T.S.

Fig.

Date:
MAR 2016

Drawn By:
F.S.M.

Checked By:
P.E.B.

Project No.:
15184

1

Appendix A

Subsurface Investigation

Subsurface Investigation Procedures (1 page)

Identification of Soil (1 page)

Test Boring Notes (1 page)

Test Boring Logs (9 pages)

Previous Test Boring Log by GeoConcepts (1 page)

Previous Test Boring Logs by RK&K (2 pages)

Boring Location Plan, Figure 2 (1 page)

Subsurface Investigation Procedures

1. Test Borings – Hollow Stem Augers

The borings are advanced by turning an auger with a center opening of 2-¼ or 3-¼ inches. A plug device blocks off the center opening while augers are advanced. Cuttings are brought to the surface by the auger flights. Sampling is performed through the center opening in the hollow stem auger, by standard methods, after removal of the plug. Usually, no water is introduced into the boring using this procedure.

2. Standard Penetration Tests

Standard penetration tests are performed by driving a 2 inch O.D., 1-¾ inch I.D. sampling spoon with a 140-pound hammer falling 30 inches, according to ASTM D-1586. After an initial 6 inches penetration to assure the sampling spoon is in undisturbed material, the number of blows required to drive the sampler an additional 12 inches is generally taken as the N value. In the event 30 or more blows are required to drive the sampling spoon the initial 6 inch interval, the sampling spoon is driven to a total penetration resistance of 100 blows or 18 inches, whichever occurs first.

3. Undisturbed Tube Samples

Undisturbed tube sampling is accomplished by inserting 3 inch I.D. thin walled steel tubes into the soil through the hollow stem of the augers with hydraulically actuated rams.

4. Test Boring Stakeout

The test boring stakeout was provided by GeoConcepts personnel using available site plans. Ground surface elevations were estimated from topographic information contained on the site plan provided to us and should be considered approximate. If the risk related to using approximate boring locations and elevations is unacceptable, we recommend an as-drilled survey of boring locations and elevations be completed by a licensed surveyor.

Identification of Soil

I. DEFINITION OF SOIL GROUP NAMES		ASTM D-2487	Symbol	Group Name
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines	<i>GW</i>	WELL GRADED GRAVEL
			<i>GP</i>	POORLY GRADED GRAVEL
		Gravels with Fines More than 12% fines	<i>GM</i>	silty GRAVEL
			<i>GC</i>	clayey GRAVEL
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines	<i>SW</i>	WELL GRADED SAND
			<i>SP</i>	POORLY GRADED SAND
		Sands with fines More than 12% fines	<i>SM</i>	silty SAND
			<i>SC</i>	clayey SAND
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	Inorganic	<i>CL</i>	LEAN CLAY
			<i>ML</i>	SILT
		Organic	<i>OL</i>	ORGANIC CLAY
				ORGANIC SILT
	Silts and Clays Liquid Limit 50 or more	Inorganic	<i>CH</i>	FAT CLAY
			<i>MH</i>	ELASTIC SILT
		Organic	<i>OH</i>	ORGANIC CLAY
				ORGANIC SILT
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor		<i>PT</i>	PEAT

II. DEFINITION OF MINOR COMPONENT PROPORTIONS

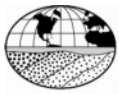
<u>Minor Component</u>	<u>Approximate Percentage of Fraction by Weight</u>
Gravelly, Sandy (adjective)	30% or more coarse grained
Sand, Gravel	15% to 29% coarse grained
Silt, Clay	5% to 12% fine grained

III. GLOSSARY OF MISCELLANEOUS TERMS

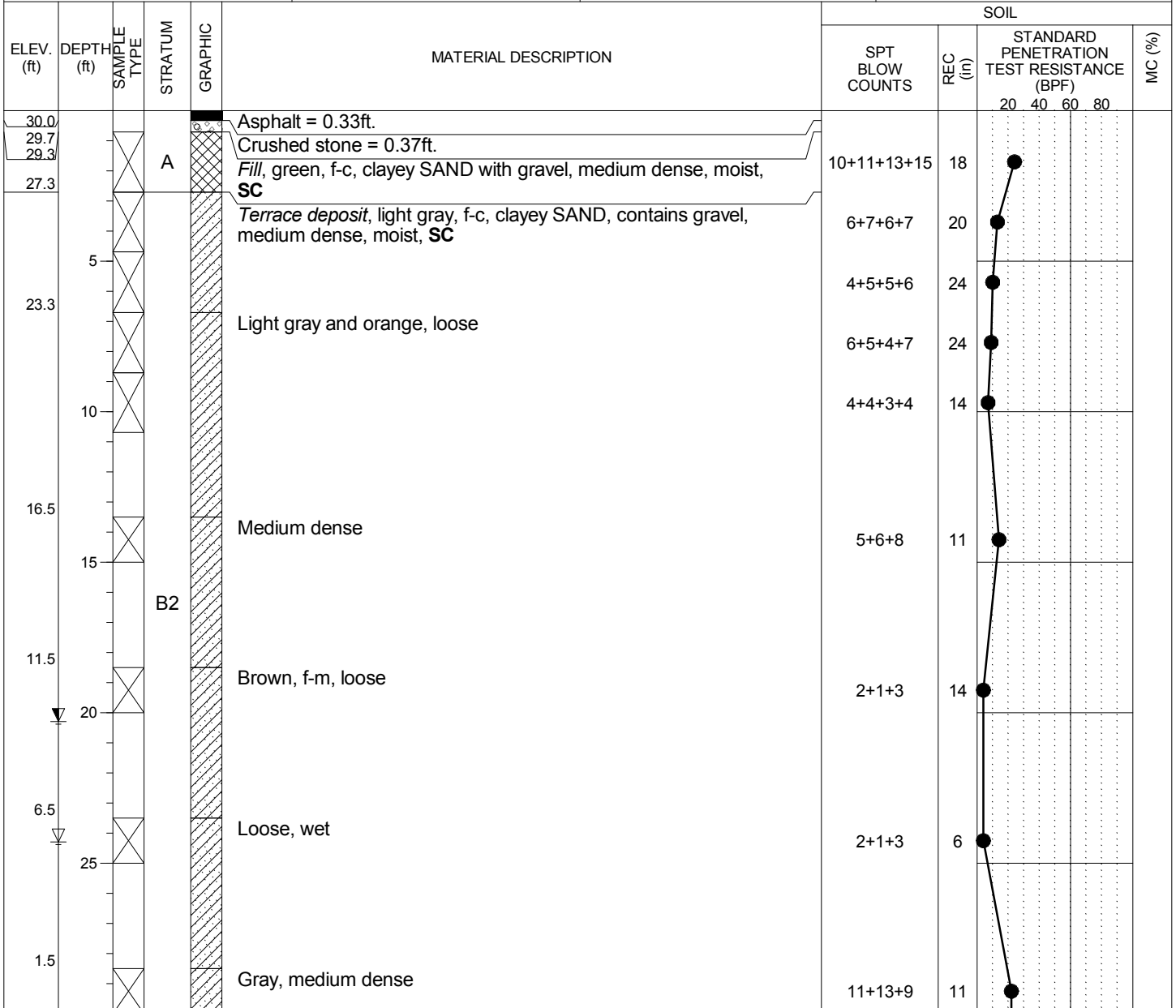
SYMBOLS	Unified Soil Classification Symbols are shown above as group symbols. Use "A" Line Chart for laboratory identification. Dual symbols are used for borderline classification.
BOULDERS & COBBLES	Boulders are considered pieces of rock larger than 12 inches, while cobbles range from 3 to 12 inches.
WEATHERED ROCK	Residual rock material with a standard penetration test (SPT) resistance of at least 60 blows per foot.
ROCK/SPOON REFUSAL	Rock material with a standard penetration test (SPT) resistance of 50 blows for 1 inch.
ROCK FRAGMENTS	Angular pieces of rock which have separated from original vein or strata and are present in a soil matrix. Only used in residual soils
QUARTZ	A hard silicate mineral often found in residual soils. Only used when describing residual soils.
CEMENTED SAND	Usually localized rock-like deposits within a soil stratum composed of sand grains cemented by calcium carbonate, iron oxide, or other minerals. Commonly encountered in Coastal Plain sediments, primarily in the Potomac Group sands (Kps).
MICACEOUS	A term used to describe soil that "glitters" or is shiny. Most commonly encountered in fine-grained soils.
ORGANIC MATERIALS (Excluding Peat)	Topsoil - Surface soils that support plant life and contain organic matter.
FILL	Lignite - Hard, brittle decomposed organic matter with low fixed carbon content (a low grade of coal).
CONTAINS	Man-made deposit containing soil, rock, and other foreign matter.
WITH	This is used when a fill deposit contains a secondary component that does not apply to a USCS classification. Only used for fill deposits
PROBABLE FILL	This is used when a residual soil contains a secondary component that does not contribute to its USCS classification. Only used for natural soils.
LAYERS	Soils which contain no visually detected foreign matter but which are suspect with regard to origin.
COLOR	1/2 to 12 inch seam of minor soil component.
MOISTURE CONDITIONS	Two most predominant colors present should be described.
GAIN SIZE	Wet, moist, or dry to indicate visual appearance of specimen.
	Fine-medium-coarse

Test Boring Notes

1. Classification of soil is by visual inspection and is in accordance with ASTM D-2488.
2. Estimated groundwater levels are indicated on the logs. These are only estimates from available data and may vary with precipitation, porosity of soil, site topography, etc.
3. Sampling data presents standard penetrations for 6-inch intervals or as indicated with graphic representations adjacent to the sampling data. Where undisturbed tube samples are taken, they are designated "Shelby Tube" on the test boring log. The column with the header of the letters "PP" stands for pocket penetrometer, which is a measure of undrained shear strength (S_u).
4. The logs and related information depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at the test locations. Also, the passage of time may result in a change in the subsurface conditions at the test locations.
5. The stratification lines represent the approximate boundary between soil types as determined in the sampling operation. Some variation may be expected vertically between samples taken. The soil profile, groundwater level observations and penetration resistances presented on the logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.
6. The information presented in the PP column is the results of pocket penetrometer readings on soil samples obtained from the split spoon. The pocket penetrometer is a hand-held instrument used to measure shear strength, which indicates unconfined compressive strength.



PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: F. Madrona	BORING NUMBER: B-1
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 10/26/15 - 10/26/15
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 30.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:



GROUND WATER LEVELS:

▽ ENCOUNTERED: 24.3 ft ELEV. 5.7

▽ UPON COMPLETION: 20.3 ft ELEV. 9.7

CAVED: 19.2 ft ELEV. 10.8

SAMPLE TYPES:



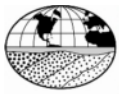
Split Spoon



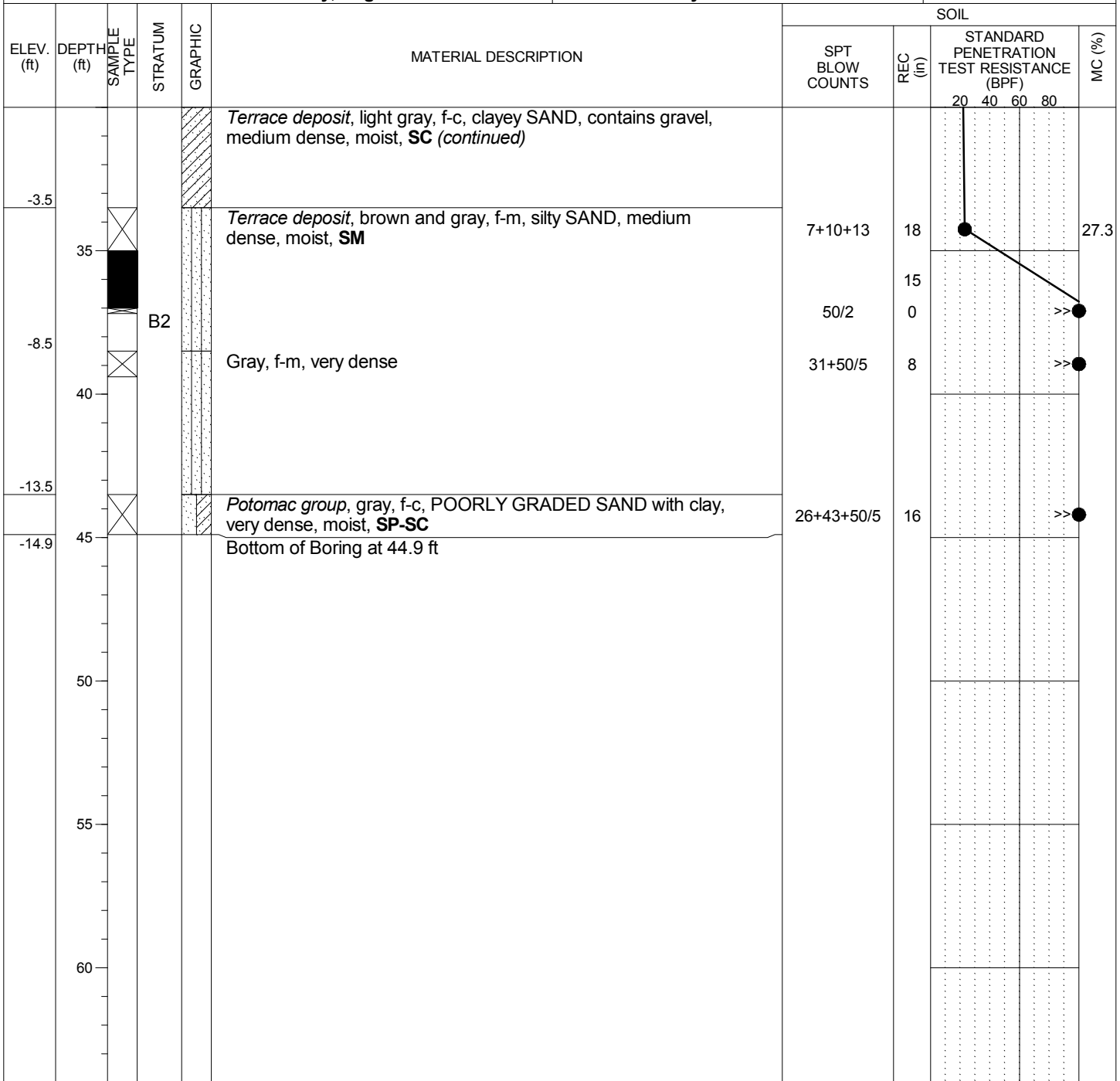
Shelby Tube

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



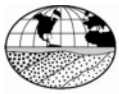
PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: F. Madrona	BORING NUMBER: B-1
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
SHEET 2 OF 2			



GROUND WATER LEVELS:		SAMPLE TYPES:	
ENCOUNTERED:	24.3 ft ELEV. 5.7		Split Spoon
UPON COMPLETION:	20.3 ft ELEV. 9.7		Shelby Tube
CAVED: 19.2 ft ELEV. 10.8			

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: B-2
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 10/23/15 - 10/23/15
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 32.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:

ELEV. (ft)	DEPTH (ft)	SAMPLE TYPE	STRATUM	GRAPHIC	MATERIAL DESCRIPTION	SOIL			
						SPT BLOW COUNTS	REC (in)	STANDARD PENETRATION TEST RESISTANCE (BPF)	MC (%)
32.0					Asphalt = 0.1ft.				
31.9					Crushed stone = 0.7ft.				
31.2			A		Fill, black and gray, f-m, LEAN CLAY with sand, firm, moist, CL	6+4+3+4	11		21.5
31.2					Pocket Penetrometer = 1.75 tsf				
29.3					Terrace deposit, gray, FAT CLAY, very stiff, moist, CH	6+8+11+4	16		29.4
29.3					Pocket Penetrometer = 0.75 tsf				
27.3					Gray and orange, with gravel, soft	2+2+2+3	5		
27.3	5				Pocket Penetrometer = 0.25 tsf				
25.3					Terrace deposit, gray and orange, LEAN CLAY, stiff, moist, CL	6+5+4+9	18		
25.3					Pocket Penetrometer = 0.75 tsf				
23.3					Terrace deposit, gray and orange, f-m, sandy FAT CLAY, very stiff, moist, CH	8+12+11+14	16		
23.3	10		B1		Pocket Penetrometer = 4.5 tsf				
18.5					Terrace deposit, gray and orange, f, sandy LEAN CLAY, firm, moist, CL	5+4+3	18		
18.5	15				Pocket Penetrometer = 1.75 tsf				
						3+4+3	18		
12.0	20				Bottom of Boring at 20.0 ft				
	25								

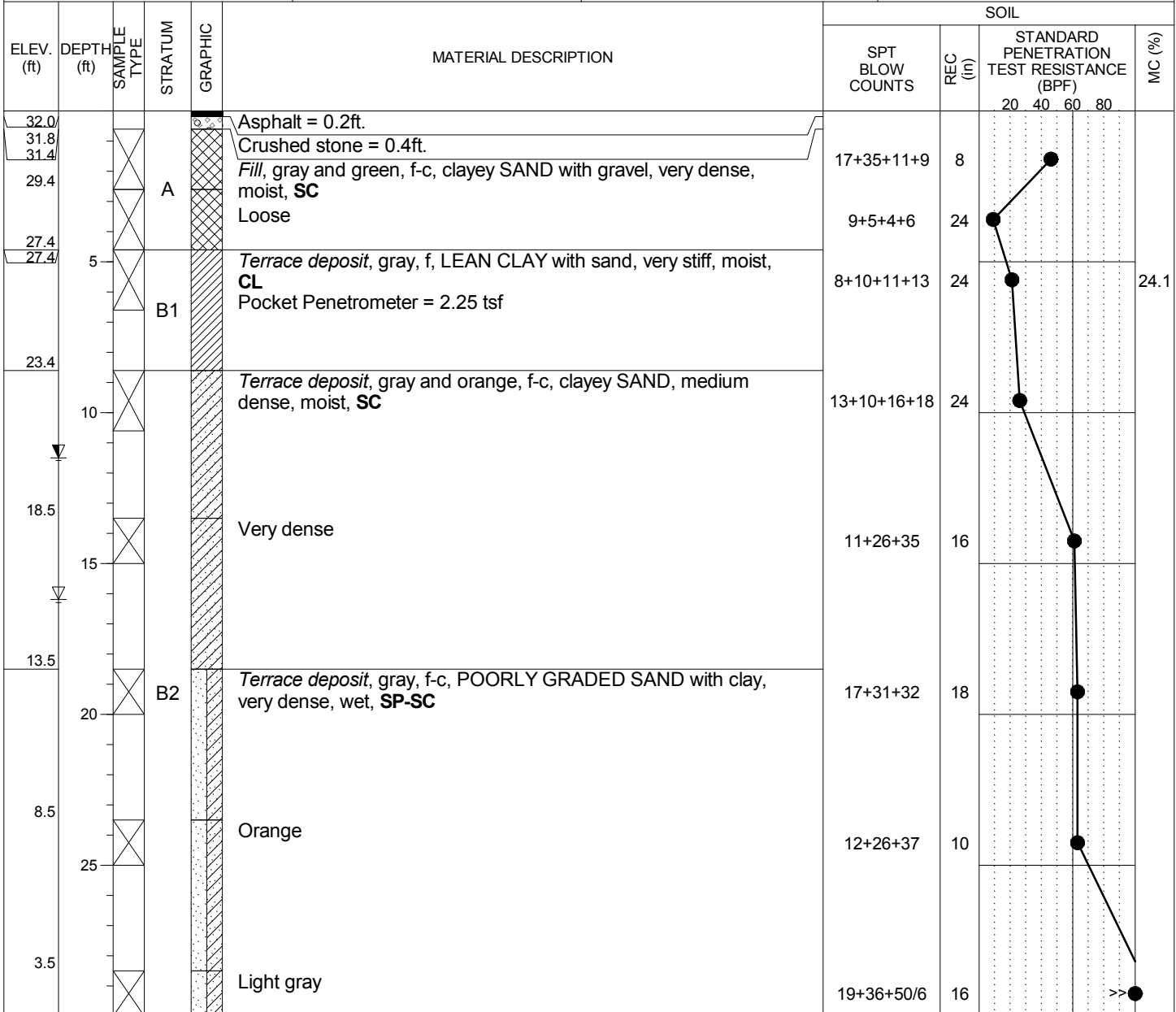
GROUND WATER LEVELS: NOT ENCOUNTERED DURING DRILLING UPON COMPLETION: <u>13.4</u> ft ELEV. <u>18.6</u> CAVED: <u>19.4</u> ft ELEV. <u>12.6</u>	SAMPLE TYPES: <input checked="" type="checkbox"/> Split Spoon
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REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: F. Madrona	BORING NUMBER: B-3
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 10/26/15 - 10/26/15
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 32.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:



GROUND WATER LEVELS:

ENCOUNTERED: 16.2 ft ELEV. 15.8

UPON COMPLETION: 11.5 ft ELEV. 20.5

CAVED: 23.5 ft ELEV. 8.5

SAMPLE TYPES:



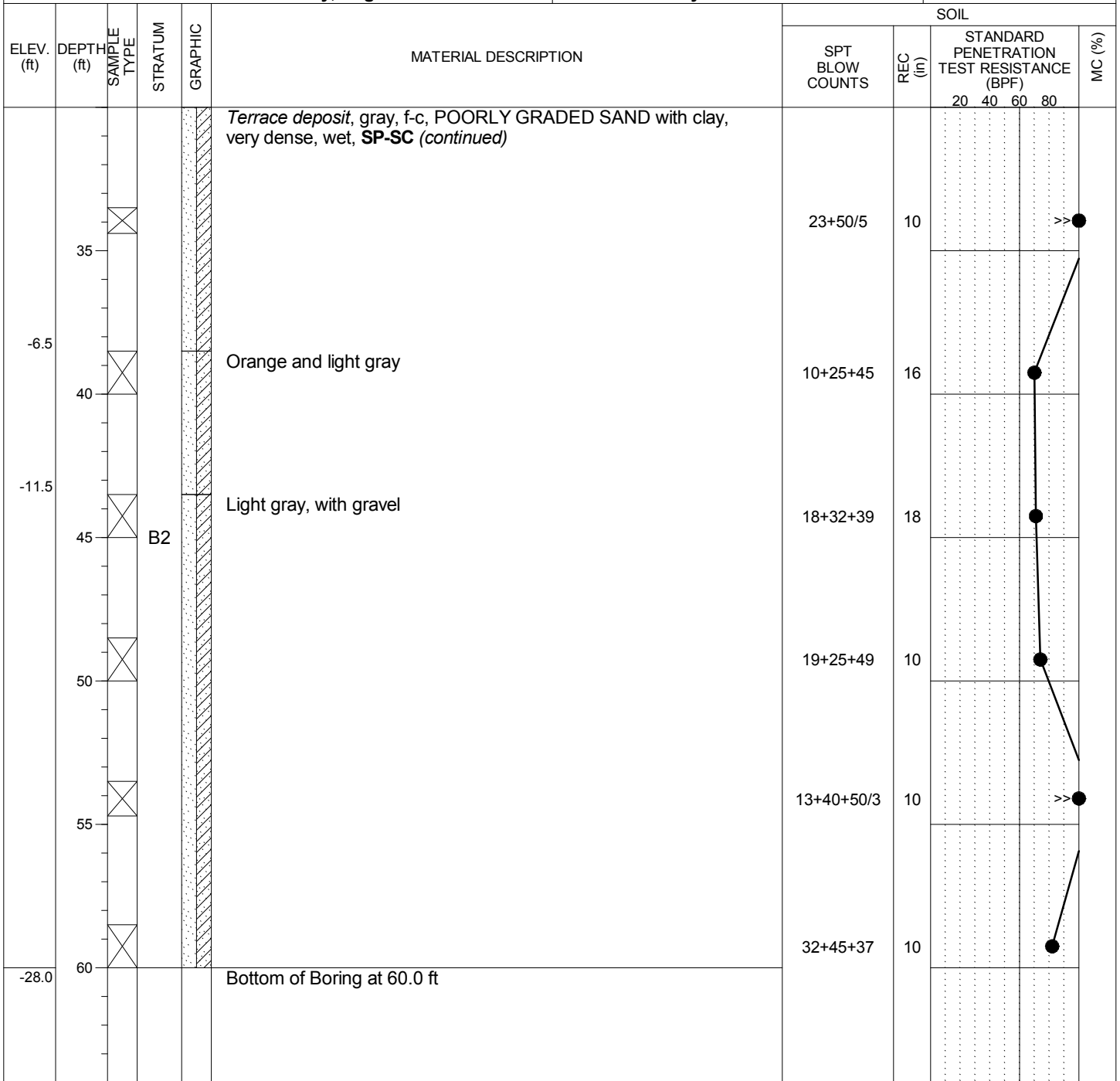
Split Spoon

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project	LOGGED BY: F. Madrona	BORING NUMBER: B-3
LOCATION: Prince William County, Virginia	DRILLING CONTRACTOR: Connelly & Associates Inc.	
		SHEET 2 OF 2



GROUND WATER LEVELS:	SAMPLE TYPES:
▽ ENCOUNTERED: <u>16.2</u> ft ELEV. <u>15.8</u> ▽ UPON COMPLETION: <u>11.5</u> ft ELEV. <u>20.5</u> CAVED: <u>23.5</u> ft ELEV. <u>8.5</u>	☒ Split Spoon

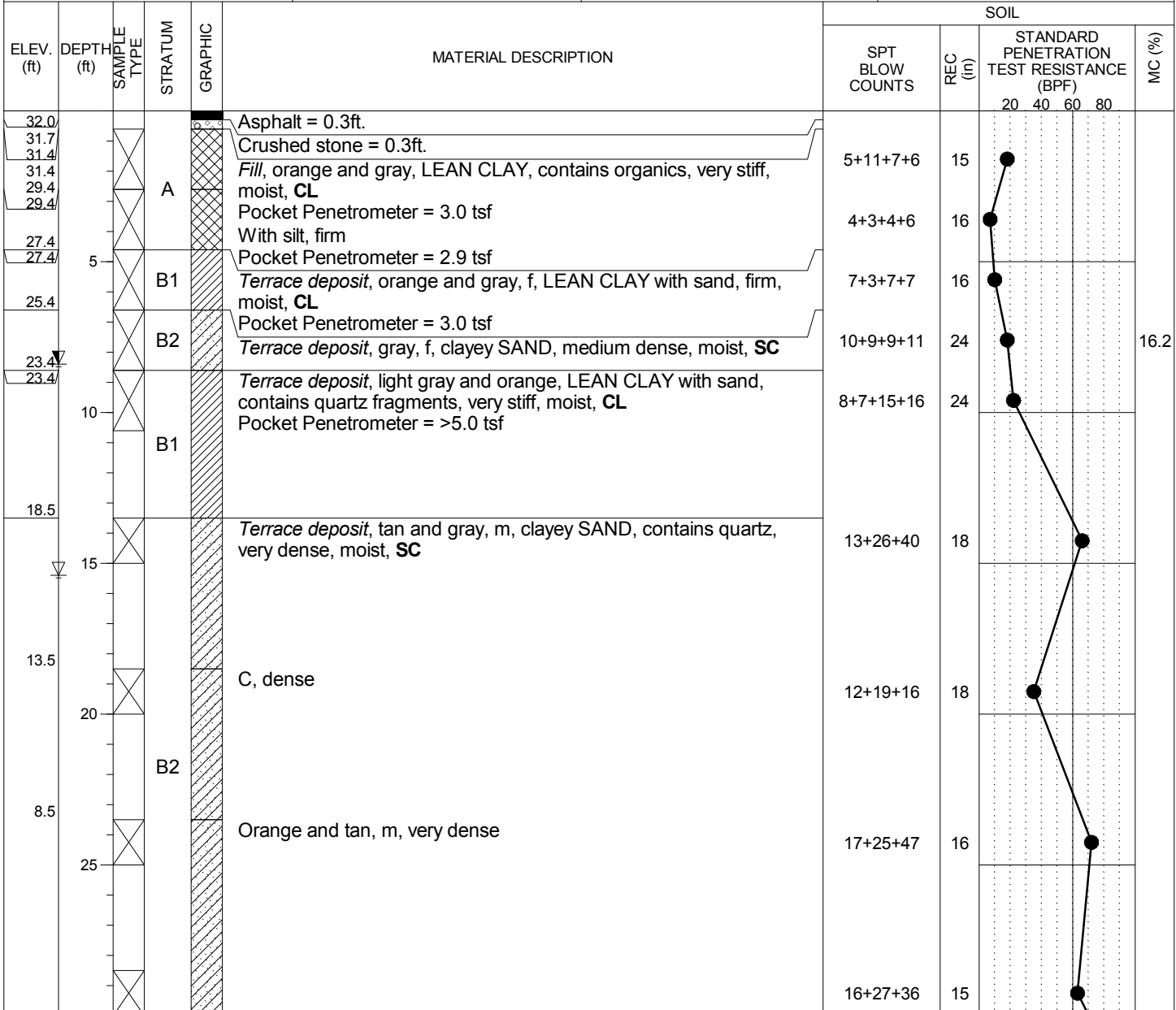
REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

BOREHOLE/TEST PIT ARKENDALE TO POWELLS LOGS.GPJ GEOCONCEPTS TEMPLATE 02-12-2015.GDT 3/28/16



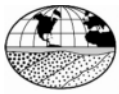
PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: B-4
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 10/23/15 - 10/23/15
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 32.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:



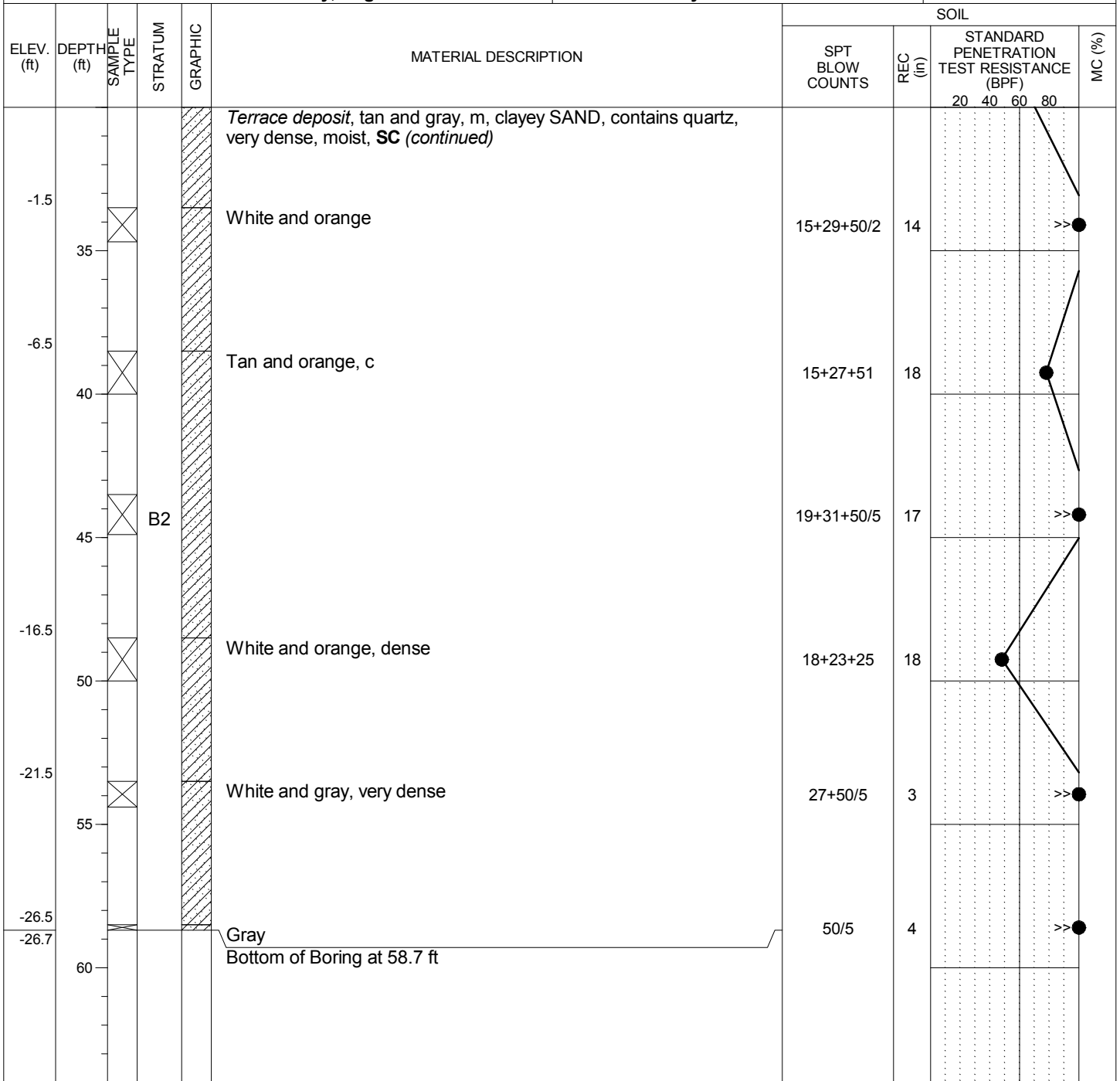
GROUND WATER LEVELS:		SAMPLE TYPES:
ENCOUNTERED:	15.4 ft ELEV. 16.6	<input checked="" type="checkbox"/> Split Spoon
UPON COMPLETION:	8.4 ft ELEV. 23.6	
CAVED: 19.3 ft ELEV. 12.7		

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project	LOGGED BY: M. Showalter	BORING NUMBER: B-4
LOCATION: Prince William County, Virginia	DRILLING CONTRACTOR: Connelly & Associates Inc.	
		SHEET 2 OF 2

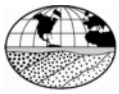


GROUND WATER LEVELS:	SAMPLE TYPES:
▽ ENCOUNTERED: <u>15.4</u> ft ELEV. <u>16.6</u> ▽ UPON COMPLETION: <u>8.4</u> ft ELEV. <u>23.6</u>	Split Spoon
CAVED: <u>19.3</u> ft ELEV. <u>12.7</u>	

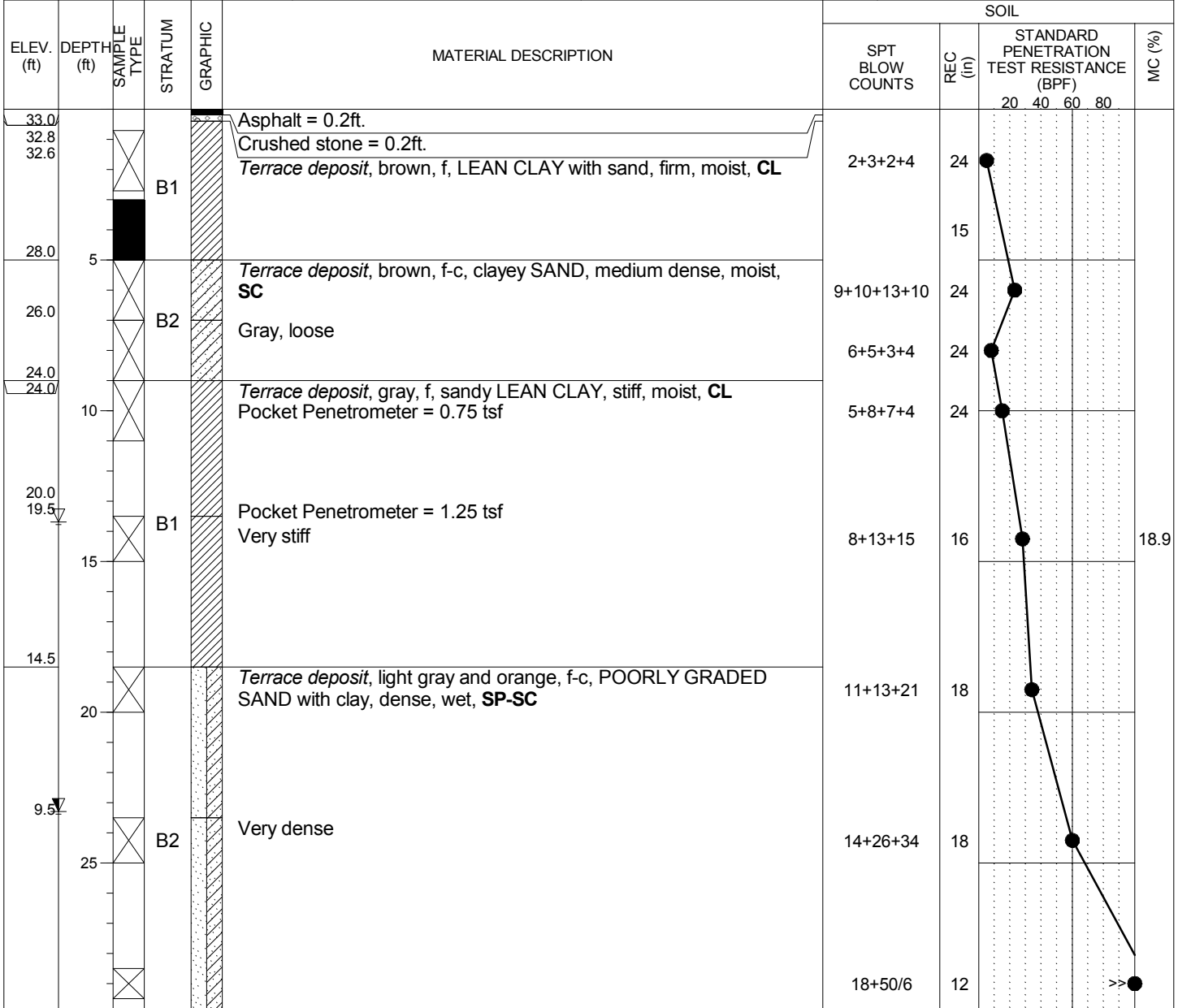
REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

BOREHOLE/TEST PIT ARKENDALE TO POWELLS LOGS.GPJ GEOCONCEPTS TEMPLATE 02-12-2015.GDT 3/28/16



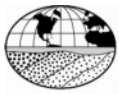
PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: F. Madrona	BORING NUMBER: B-5
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 10/27/15 - 10/27/15
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 33.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:



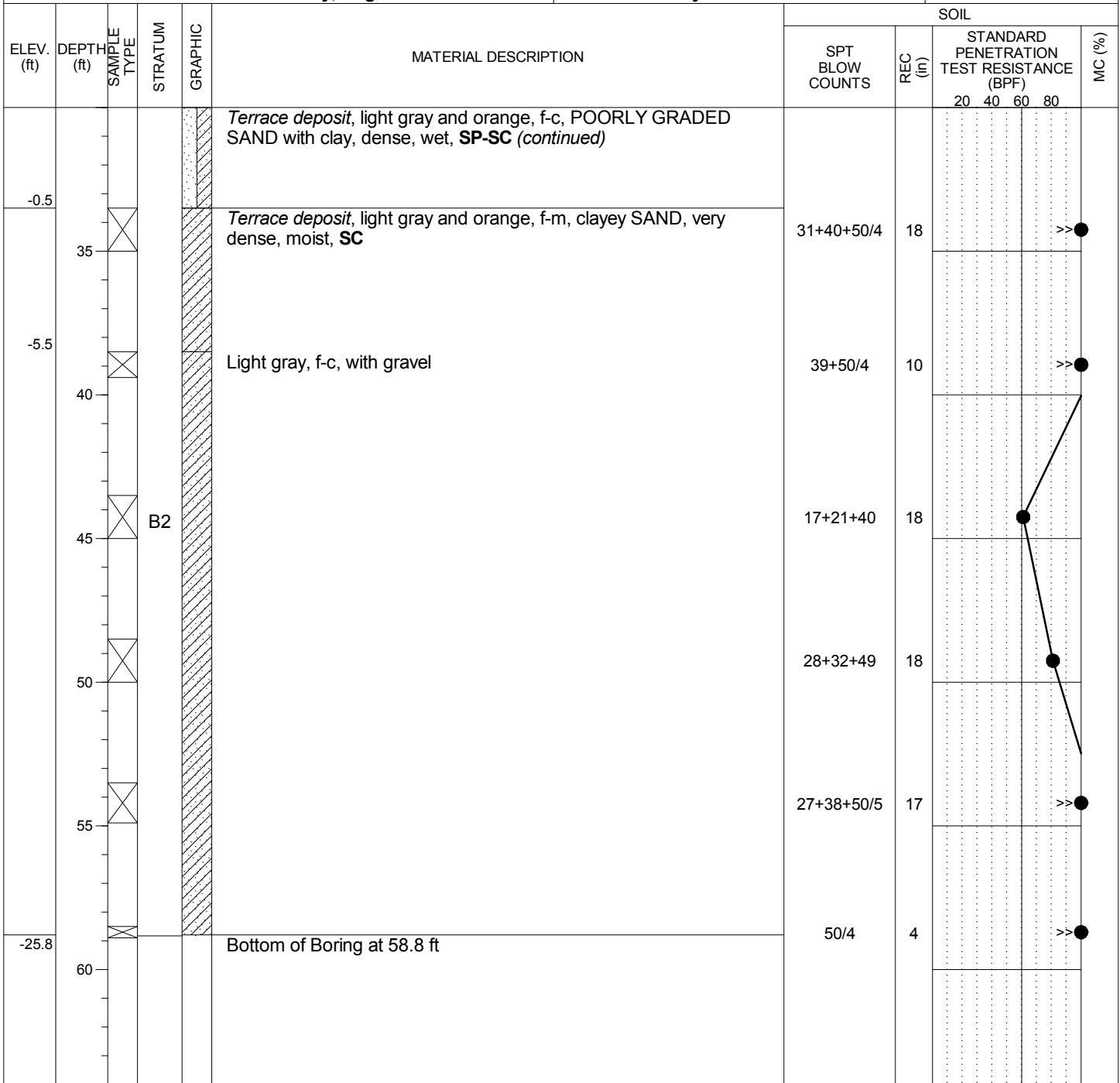
GROUND WATER LEVELS:				SAMPLE TYPES:			
ENCOUNTERED:	13.7	ft	ELEV.	19.3	Split Spoon Shelby Tube		
UPON COMPLETION:	23.3	ft	ELEV.	9.7			
CAVED:				25.2	ft	ELEV.	7.8

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project	LOGGED BY: F. Madrona	BORING NUMBER: B-5
LOCATION: Prince William County, Virginia	DRILLING CONTRACTOR: Connelly & Associates Inc.	
		SHEET 2 OF 2



GROUND WATER LEVELS:		SAMPLE TYPES:	
ENCOUNTERED:	13.7 ft ELEV. 19.3		Split Spoon
UPON COMPLETION:	23.3 ft ELEV. 9.7		Shelby Tube
CAVED: 25.2 ft ELEV. 7.8			

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



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Ashburn, Virginia 703-726-8030 fax

SHEET 1 OF 1

[illegible]

GROUND WATER LEVELS:

ENCOUNTERED: None

			SAMPLE TYPES:
--	--	--	---------------

 Split Spoon

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

TEST BORING LOG

Boring No. T-035

Page 1 of 1

PROJECT: Arkendale-Powell's Creek (Cherry Hill) Third Track SITE: Stafford and Prince William Counties, Virginia DRILLING CO.: F&R RIG/HAMMER: CME55 Track / Auto										COMMISSION NO.: 14-008-500 NORTH: 6874976 EAST: 11827903 ELEVATION: 30.5 - ft START DATE: 9/2/2014 END DATE: 9/2/2014 DRILLER: C. Sequist LOGGED BY: MRS							
GROUNDWATER DATA (ft)										EQUIPMENT		CASING		SAMPLER		CORE	
Date		Time		Water		Casing		Cave-In		TYPE		HSA		S			
9/2/2014		2:00:00 PM		18				6.5		SIZE, ID (in)		3.25		1.375			
										HAMMER WT. (lb)		140		-			
										HAMMER FALL (in)		30		-			

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in)	BLOWS/6" (% RQD)	LABORATORY TEST RESULTS			DEPTH	ELEV. DEPTH	GRAPHIC	DESCRIPTION AND CLASSIFICATION (moisture, density, color, proportions, etc.)	NOTES:
				NMC/ Frac. Freq.	LIQUID LIMIT	PLASTICITY INDEX					
S-1	X	5	5 3 5	10.5%	29	12	EL 29.8 0.7		8-in Topsoil	Bulk Sample Taken From Auger Cuttings From 1 to 8-ft	
S-2	X	18	4 5 7	11.1%		5	EL 27.5 3.0		FILL, Sampled As: Moist, Loose, Black to Tan, Coarse to Fine Subrounded GRAVEL, Some Clay, Little Medium to Fine Sand Moist, Medium Dense, Tan, Coarse to Fine SAND, Some Silt (sm) {a-2-4}		
S-3	X	15	7 7 8						Sample S-3: Orange-Brown, Medium to Fine, Trace Clay		
S-4	X	18	2 2 3			10	EL 22.5 8.0		Moist, Medium Stiff, Gray to Orange-Brown, High Plasticity CLAY, And Medium to Fine Sand (CL) {A-7-6}		
S-5	X	12	1 1 2	27.4%	48	34			Sample S-5: Soft, Gray, Little Silt, Little Medium to Fine Sand		
S-6	X	16	WOH 2 4			15			Sample S-6: Little Silt, Trace Medium to Fine Sand		
S-7	X	18	WOH 2 3				EL 15.0 15.5		Moist, Loose, Gray to Orange-Brown, Coarse to Fine SAND, Some Clay (sc) {a-2-6}		
S-8	X	11	2 3 5			20	EL 12.5 18.0		Moist, Loose, Gray, Coarse to Fine SAND, Trace Silt (sp) {a-1-b}	Water On Rods At 18-ft	
S-9	X	18	4 8 8			25	EL 5.5 25.0		Sample S-9: Medium Dense, Orange-Brown to White, Trace Medium to Fine Subrounded Gravel Bottom of Boring @ 25.0 ft	Boring Backfilled Upon Completion	

SAMPLE IDENTIFICATION		DRILLING METHOD		BLOWS/FT	DENSITY	BLOWS/FT	CONSISTENCY	SAMPLE PROPORTIONS (PERCENT)	
	- S - SPLIT SPOON	HSA - HOLLOW STEM AUGERS		0-4	VERY LOOSE	0-2	VERY SOFT	TRACE	1 TO 10
	- T - THIN WALL TUBE	SSA - SOLID STEM AUGERS		5-10	LOOSE	3-4	SOFT	LITTLE	11 TO 20
	- SS - 3" SPLIT SPOON	DC - DRIVING CASING		11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	SOME	21 TO 35
	- D - DENISON	MD - MUD DRILLING		31-50	DENSE	9-15	STIFF	AND	36 TO 50
	- RC - ROCK CORE	HA - HAND AUGER		OVER 50	VERY DENSE	16-30	VERY STIFF		
						OVER 30	HARD		

RKK NORTH/EAST (DEFAULT) CSX ARKENDALE.GPJ RKK_CURRENT.GDT 12/15/14

Boring No. T-035

TEST BORING LOG

Boring No. T-036
Page 1 of 1

	PROJECT: Arkendale-Powell's Creek (Cherry Hill) Third Track				COMMISSION NO.: 14-008-500								
	SITE: Stafford and Prince William Counties, Virginia				NORTH: 6875388								
	DRILLING CO.: F&R				EAST: 11828163								
	RIG/HAMMER: CME55 Track / Auto				ELEVATION: 33 - ft								
GROUNDWATER DATA (ft)					EQUIPMENT		CASING		SAMPLER		CORE		
Date		Time		Water		Casing		Cave-In		TYPE		HSA	
9/3/2014		11:15:00 AM		6.7				6.7		SIZE, ID (in)		3.25	
										HAMMER WT. (lb)		140	
										HAMMER FALL (in)		30	

START DATE: 9/3/2014
END DATE: 9/3/2014
DRILLER: C. Sequist
LOGGED BY: MRS

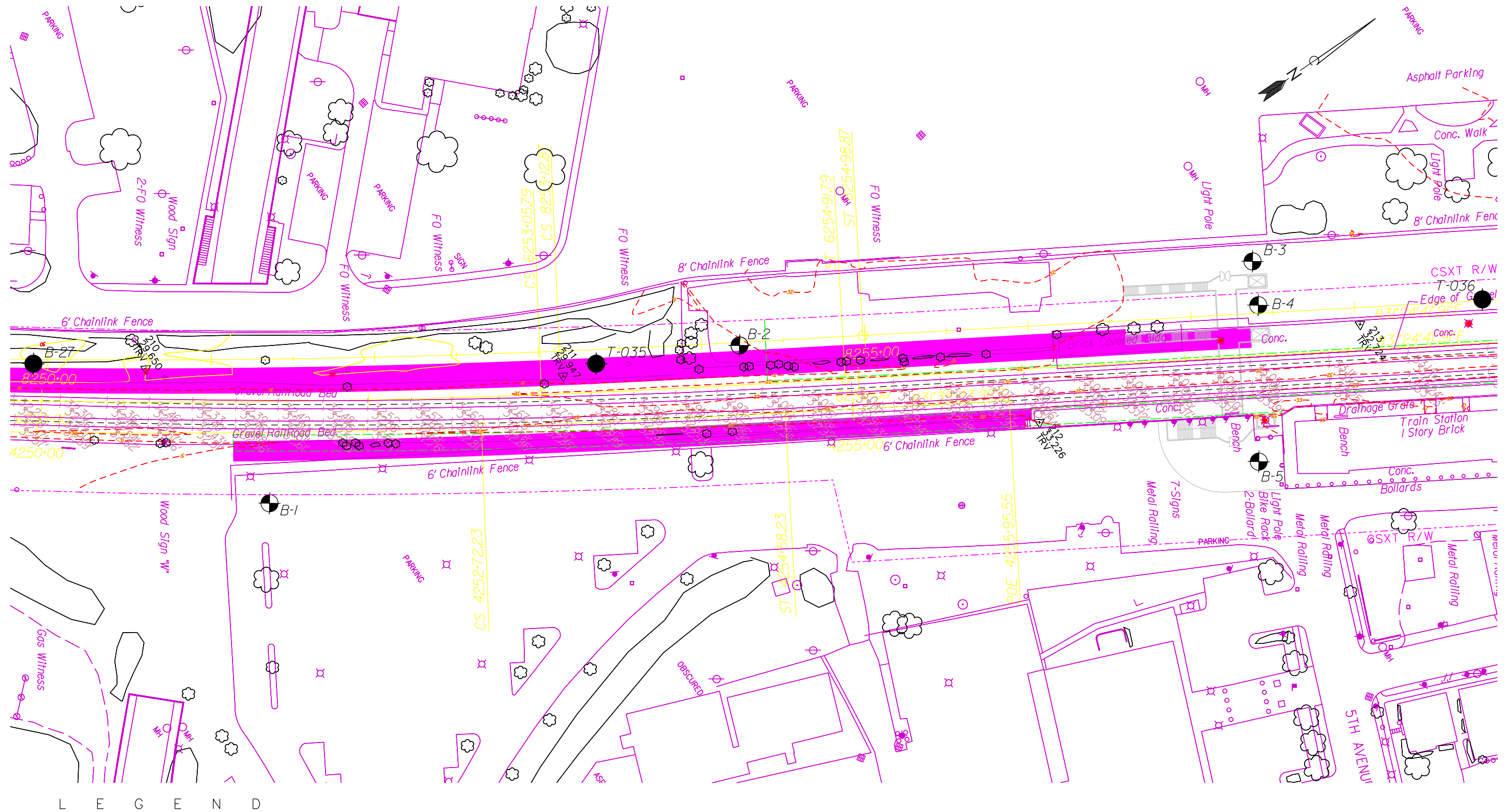
SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in)	BLOWS/6" (% RQD)	LABORATORY TEST RESULTS			DEPTH	ELEV. DEPTH	GRAPHIC	DESCRIPTION AND CLASSIFICATION (moisture, density, color, proportions, etc.)	NOTES:
				NMC/ Frac. Freq.	LIQUID LIMIT	PLASTICITY INDEX					
S-1	X	12	5 6 3	27.5%				EL 32.5 0.5		6-in Bituminous Asphalt Concrete	Bulk Sample Taken From Auger Cuttings From 2 to 8-ft
										8-in Portland Cement Concrete	
								EL 31.8 1.2		5-in Graded Aggregate Base	
								EL 31.4 1.6		FILL, Sampled As: Moist, Loose, Gray to Brown, Coarse to Fine SAND, And Clay	
S-2	X	18	2 4 7					EL 30.0 3.0		Moist, Stiff, Gray, SILT, Little Clay, Little Fine Sand (ml) {a-4}	
							5				
S-3	X	18	8 10 12					EL 27.5 5.5		Moist, Medium Dense, Gray to White, Coarse to Fine SAND, Little Silt (sm) {a-2-4}	
S-4	X	18	5 15 23					EL 25.0 8.0		Moist, Dense, Gray to White, Coarse to Fine SAND, Some Clay, Trace Silt (sc) {a-2-6}	
							10				
S-5	X	11	22 50/5"							Sample S-5: Very Dense, Orange-Brown	
S-6	X	18	19 28 35							Sample S-6: Very Dense	
							15				
S-7	X	18	19 23 32							Sample S-7: Very Dense, Gray to White to Orange-Brown, Little Silt, Trace Fine Subangular Gravel	
S-8	X	18	19 23 31							Sample S-8: Very Dense, Gray to White to Orange-Brown, Little Silt, Trace Fine Subangular Gravel	
							20				
S-9	X	17	19 23 50/5"					EL 8.0 25.0		Sample S-9: Very Dense, Gray to White to Orange-Brown, Medium to Fine, Little Silt, Trace Fine Subangular Gravel	
							25			Bottom of Boring @ 25.0 ft	
											Boring Backfilled Upon Completion, Patched With Asphalt 9/4/14

SAMPLE IDENTIFICATION		DRILLING METHOD		BLOWS/FT	DENSITY	BLOWS/FT	CONSISTENCY	SAMPLE PROPORTIONS (PERCENT)	
	- S - SPLIT SPOON	HSA - HOLLOW STEM AUGERS		0-4	VERY LOOSE	0-2	VERY SOFT	TRACE	1 TO 10
	- T - THIN WALL TUBE	SSA - SOLID STEM AUGERS		5-10	LOOSE	3-4	SOFT	LITTLE	11 TO 20
	- SS - 3" SPLIT SPOON	DC - DRIVING CASING		11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	SOME	21 TO 35
	- D - DENISON	MD - MUD DRILLING		31-50	DENSE	9-15	STIFF	AND	36 TO 50
	- RC - ROCK CORE	HA - HAND AUGER		OVER 50	VERY DENSE	16-30	VERY STIFF		
						OVER 30	HARD		

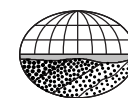
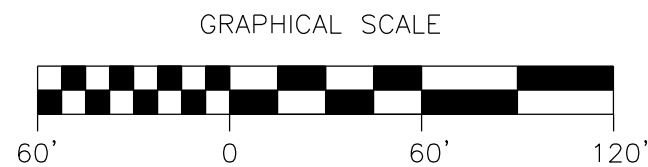
Boring No. T-036

RK&K NORTH/EAST (DEFAULT) CSX ARKENDALE.GPJ RK&K_CURRENT.GDT 11/24/14

N:\PROJECTS\Active 15 Projects\15184 - Quantico Station Design\DWG\Quantico Station BLP.dwg



- TEST BORING LOCATION
B-1
- PREVIOUS TEST BORING LOCATION



**GeoConcepts
Engineering, Inc.**

19955 Highland Vista Dr., Suite 170 (703) 726-8030
Ashburn, Virginia 20147 (703) 726-8032 fax

ARKENDALE-POWELLS CREEK THIRD TRACK PROJECT
PRINCE WILLIAM COUNTY, VIRGINIA

BORING LOCATION PLAN

Scale:
AS SHOWN

Date:
MARCH 2016

Checked By:
P.E.B.

Project No.:
15184

Fig.

2

Appendix B

Soil Laboratory Test Results

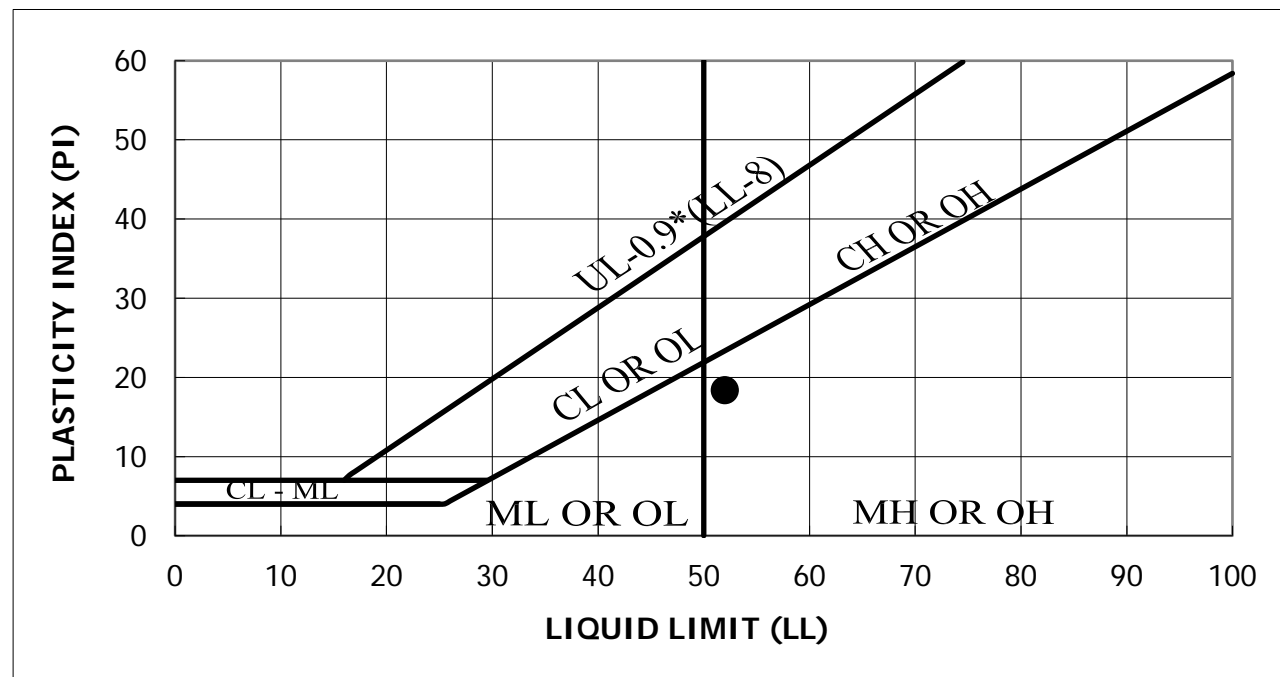
Liquid and Plastic Limit, and Grain Size Analysis Test Data (10 pages)

Corrosion Series Test Results (1 page)



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-1	Depth (Feet)	33.5'-35.0'
Lab Order No.	3667-1	Date	11/6/2015



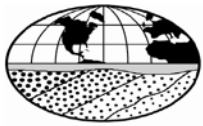
Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
SILTY SAND	52	34	18	96.4	40.6	SM	27.3
Color	Dark Gray		AASHTO Classification		A-7-5		

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Bartz

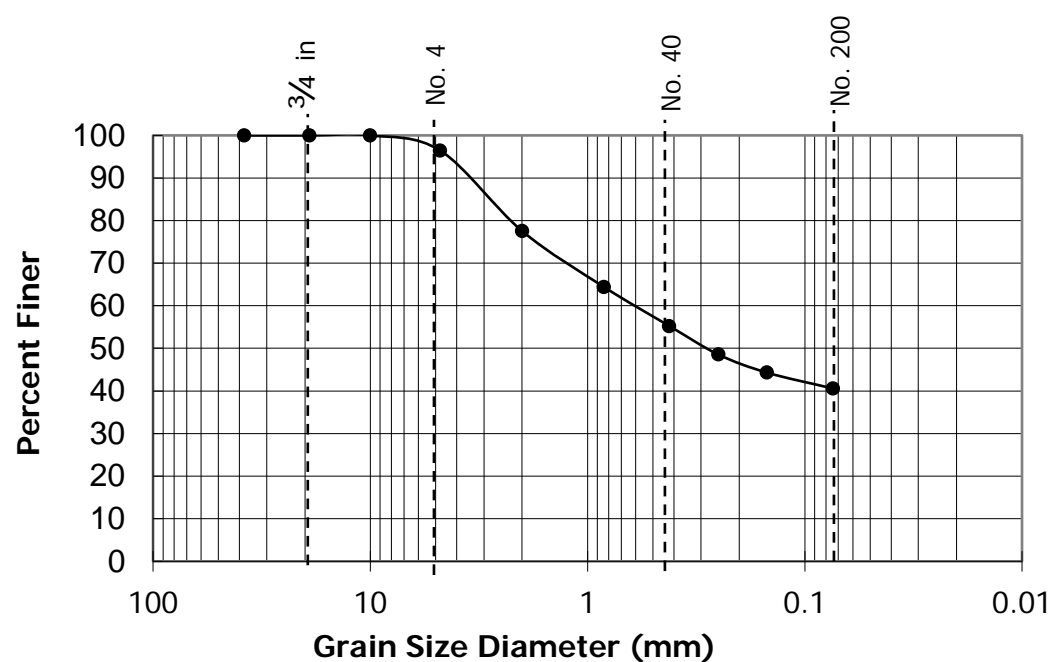


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-1	Depth (Feet)	33.5'-35.0'
Lab Order No.	3667-1	Date	11/6/2015



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	96
#10	78
#20	64
#40	55
#60	49
#100	44
#200	41
Pan	--

USCS Group Symbol	SM
USCS Group Name	SILTY SAND
Cu	---
Cc	---
LL	52
PI	18
Gravel	3.6
Sand	55.9
Fines	40.6
AASHTO Classification	A-7-5
Color	Dark Gray

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

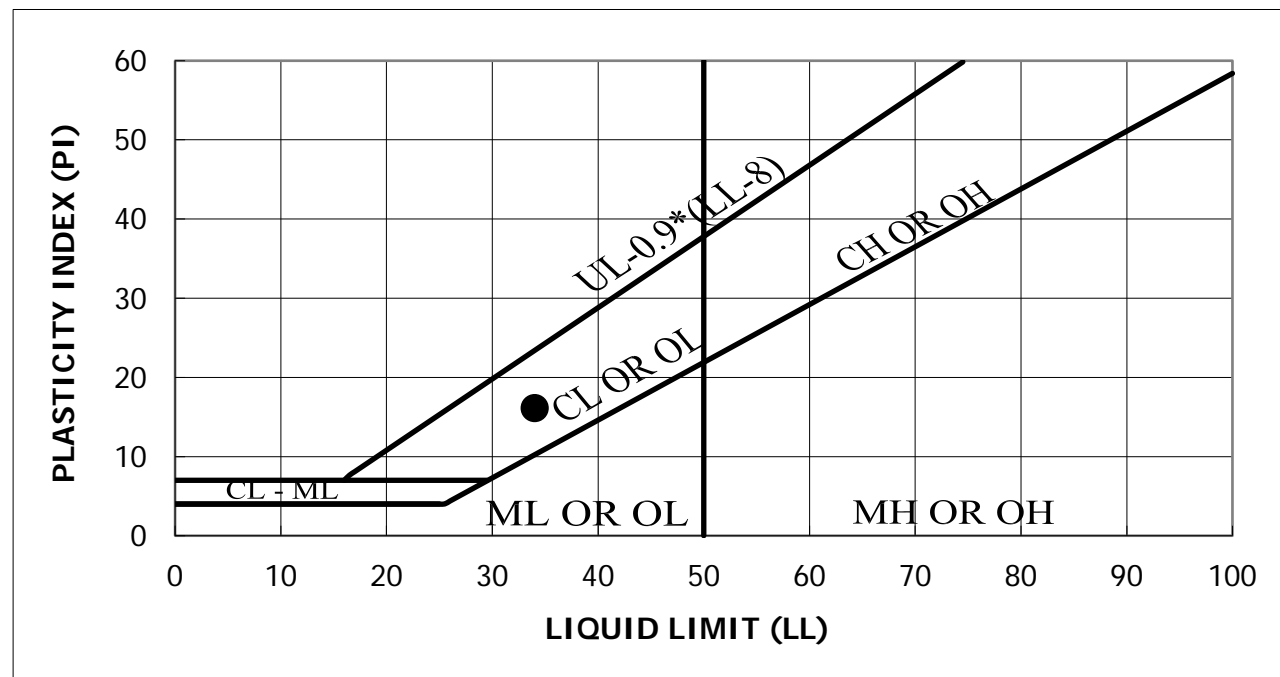
Reviewed by: _____

Lindsay Bantz



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-2	Depth (Feet)	0.7' -2.7'
Lab Order No.	3667-2	Date	11/6/2015



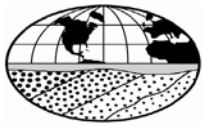
Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
Lean Clay with sand	34	18	16	99.7	83.6	CL	21.5
Color	Dark Gray		AASHTO Classification		A-6		

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Barty

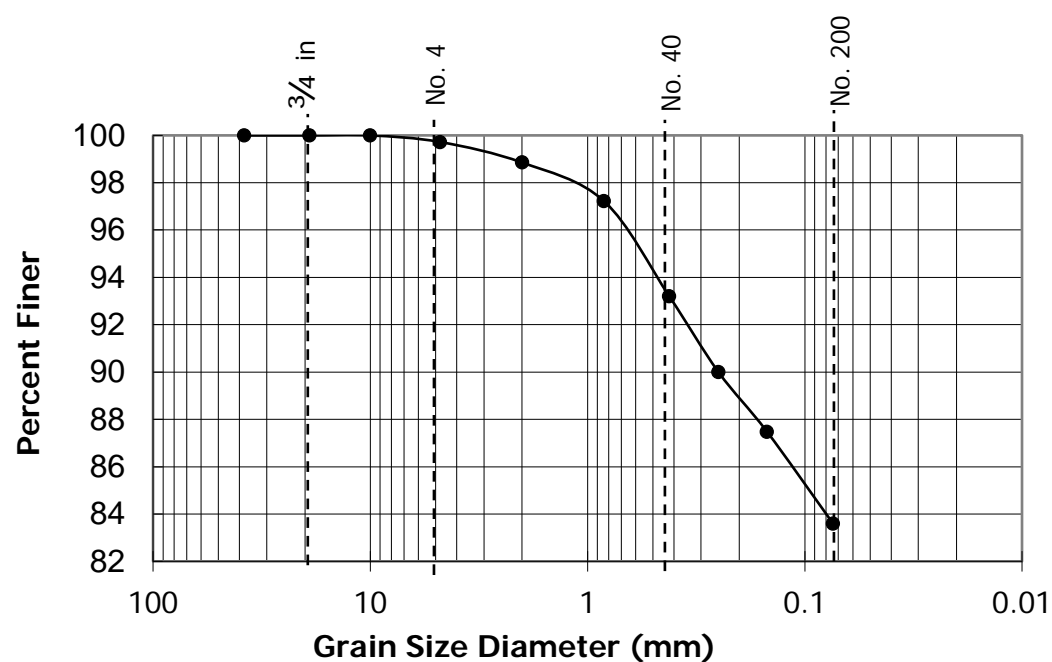


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-2	Depth (Feet)	0.7' -2.7'
Lab Order No.	3667-2	Date	11/6/2015



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	99
#20	97
#40	93
#60	90
#100	87
#200	84
Pan	--

USCS Group Symbol	CL
USCS Group Name	Lean Clay with sand
Cu	---
Cc	---
LL	34
PI	16
Gravel	0.3
Sand	16.1
Fines	83.6
AASHTO Classification	A-6
Color	Dark Gray

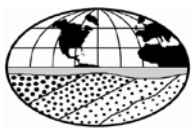
Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

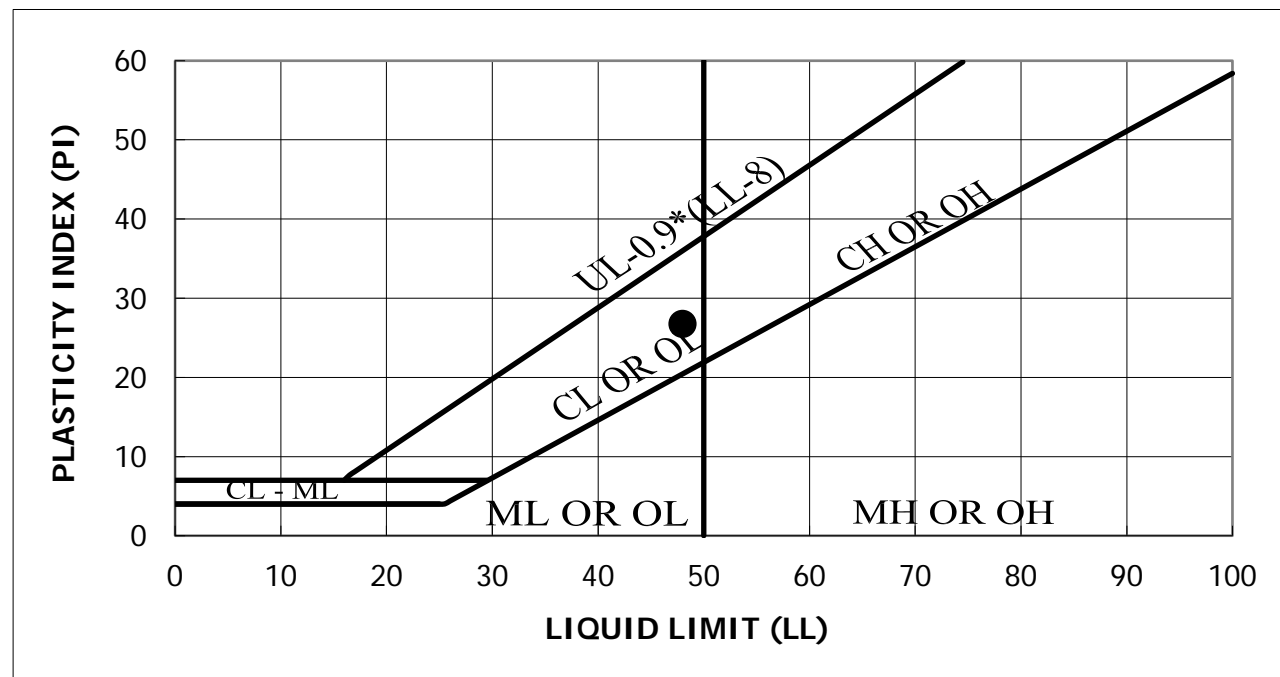
Reviewed by: _____

Lindsay Bantz



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-3	Depth (Feet)	4.6'-6.6'
Lab Order No.	3667-4	Date	11/6/2015



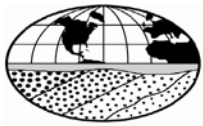
Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
Lean Clay with sand	48	21	27	100.0	85.2	CL	24.1
Color	Dark Gray		AASHTO Classification		A-7-6		

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Bantz

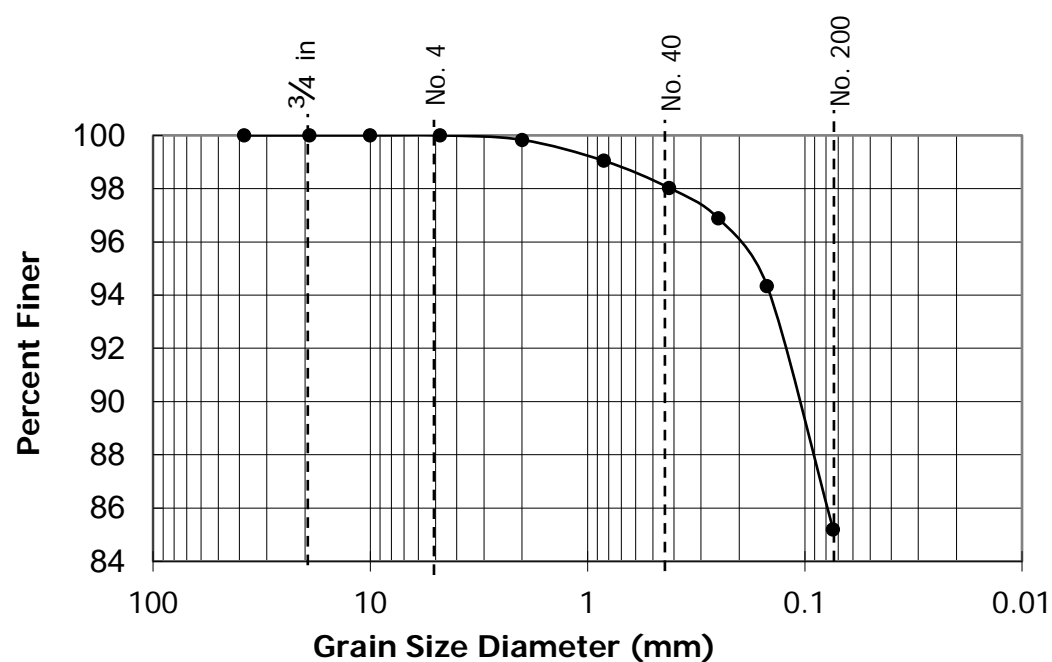


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(703) 726-8030
www.geoconcepts-eng.com

GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-3	Depth (Feet)	4.6'-6.6'
Lab Order No.	3667-4	Date	11/6/2015



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	100
#20	99
#40	98
#60	97
#100	94
#200	85
Pan	--

USCS Group Symbol	CL
USCS Group Name	Lean Clay with sand
Cu	---
Cc	---
LL	48
PI	27
Gravel	0.0
Sand	14.8
Fines	85.2
AASHTO Classification	A-7-6
Color	Dark Gray

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

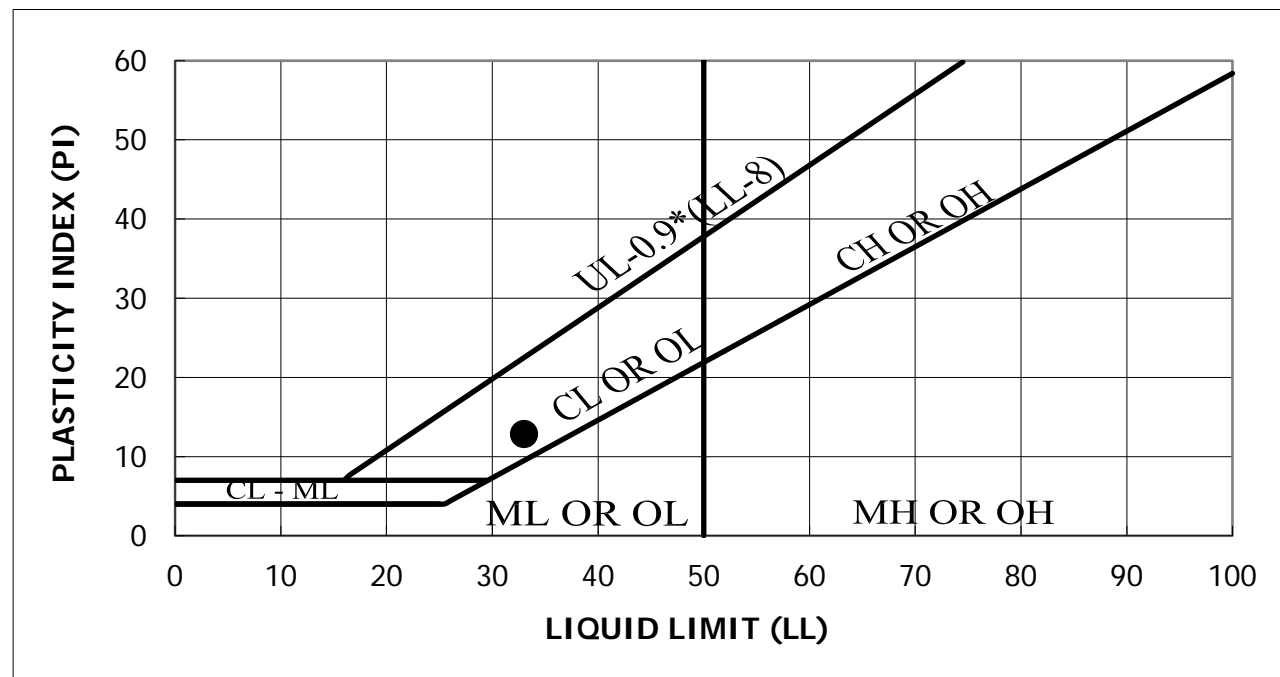
Reviewed by: _____

Lindsay Bantz



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-4	Depth (Feet)	6.6'-8.6'
Lab Order No.	3667-5	Date	11/6/2015



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
CLAYEY SAND	33	20	13	99.5	23.8	SC	16.2
Color	Gray		AASHTO Classification		A-2-6		

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

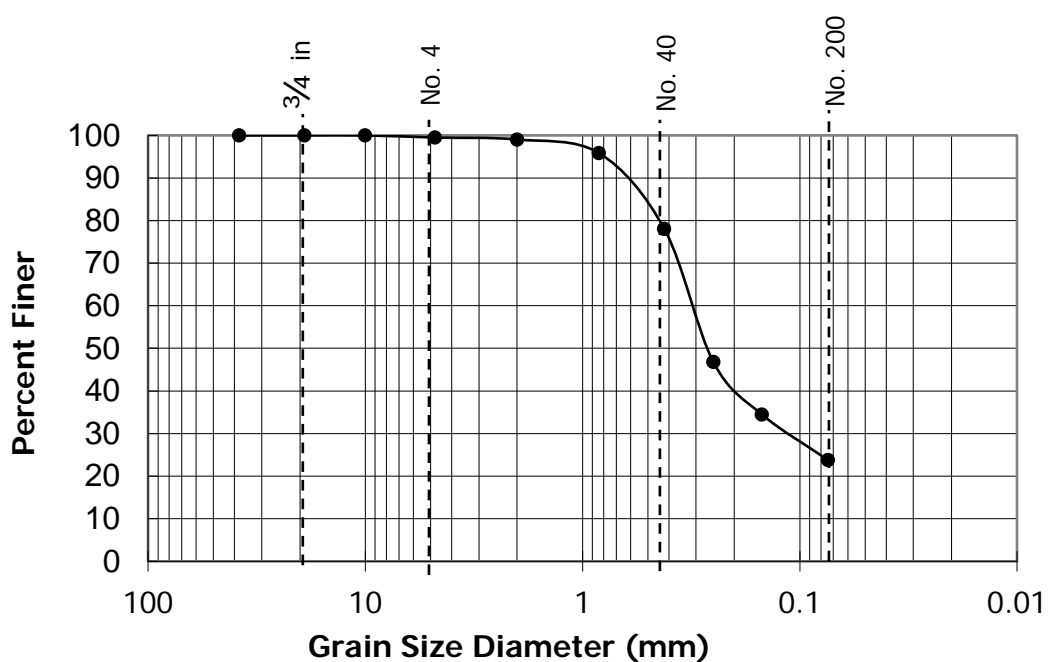
Tested by _____

Reviewed by Lindsay Barty



19955 Highland Vista Dr., Suite 170
Ashburn, Virginia 20147
(703) 726-8030
www.geoconcepts-eng.com

GRAIN SIZE ANALYSIS - ASTM D422			
Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-4	Depth (Feet)	6.6'-8.6'
Lab Order No.	3667-5	Date	11/6/2015



SIEVE	% Passing
1 ½ "	100
¾"	100
⅜"	100
#4	99
#10	99
#20	96
#40	78
#60	47
#100	34
#200	24
Pan	--

USCS Group Symbol	SC
USCS Group Name	CLAYEY SAND
Cu	---
Cc	---
LL	33
PI	13
Gravel	0.5
Sand	75.7
Fines	23.8
AASHTO Classification	A-2-6
Color	Gray

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

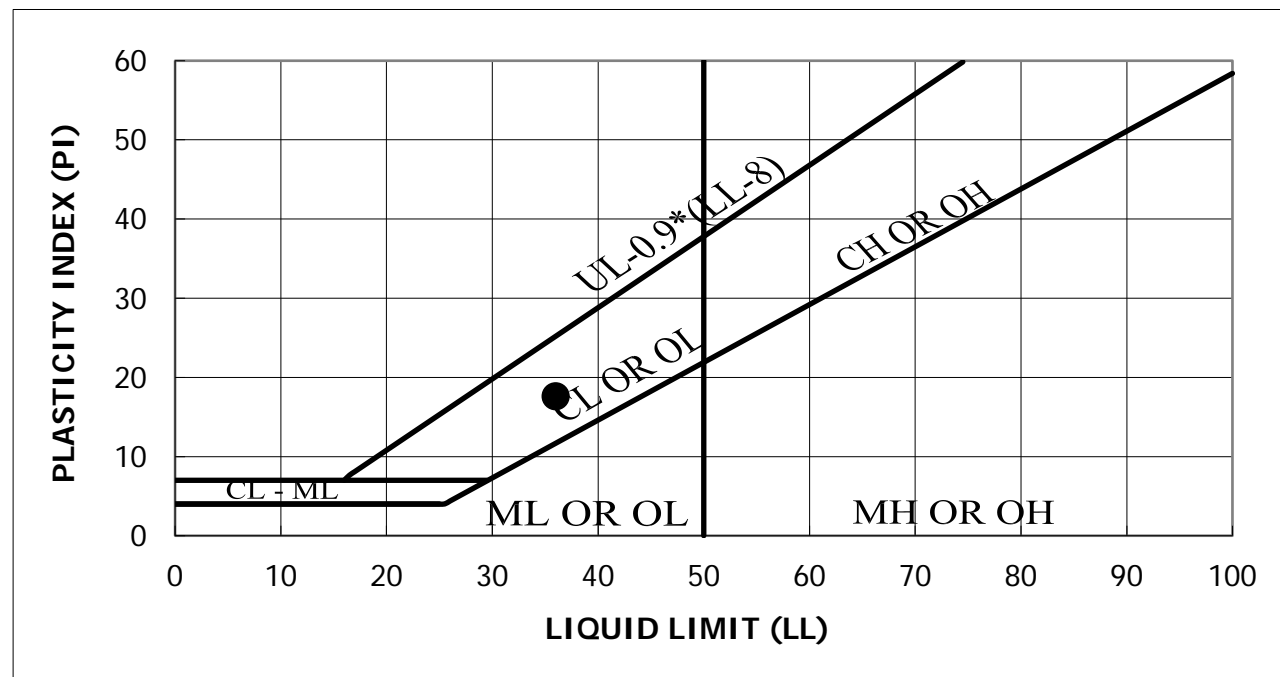
Reviewed by:

Lindsay Bantz



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-5	Depth (Feet)	13.5'-15.0'
Lab Order No.	3667-6	Date	11/6/2015



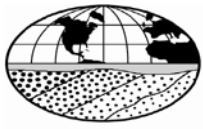
Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
sandy Lean Clay	36	18	18	100.0	54.7	CL	18.9
Color	Gray		AASHTO Classification			A-6	

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Barty

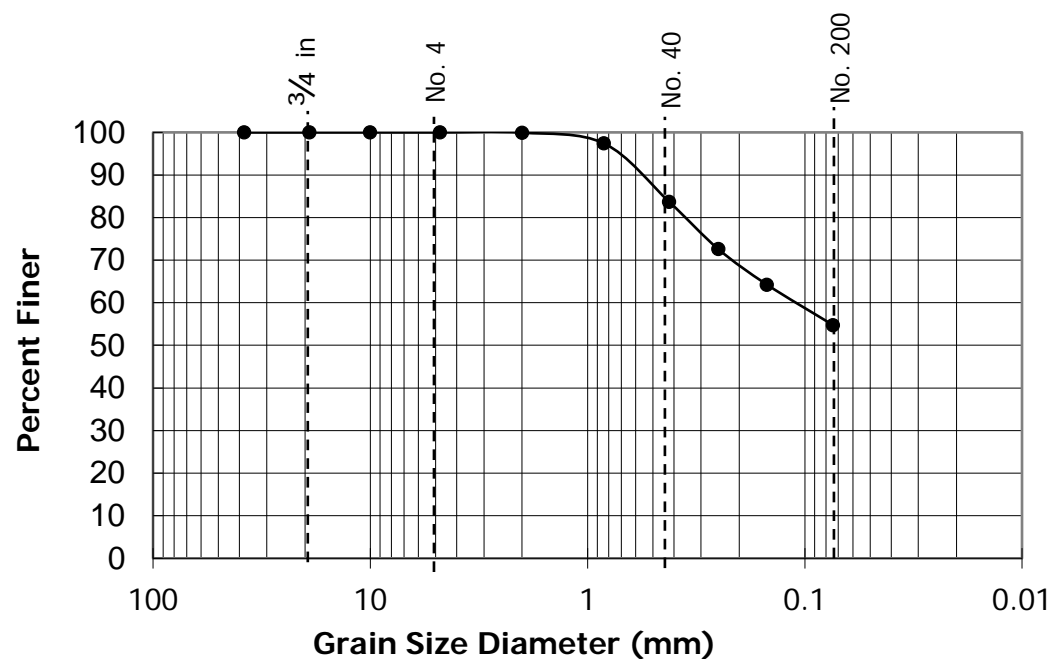


GeoConcepts Engineering, Inc.

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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184.00	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	B-5	Depth (Feet)	13.5'-15.0'
Lab Order No.	3667-6	Date	11/6/2015



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	100
#20	97
#40	84
#60	73
#100	64
#200	55
Pan	--

USCS Group Symbol	CL
USCS Group Name	sandy Lean Clay
Cu	---
Cc	---
LL	36
PI	18
Gravel	0.0
Sand	45.3
Fines	54.7
AASHTO Classification	A-6
Color	Gray

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

Reviewed by: _____

Lindsay Bantz



Report Number: **154920**

HP ENVIRONMENTAL
INCORPORATED

Page 1 of 2

Certificate of Laboratory Analysis

GeoConcepts Engineering, Inc.
Attn: Fernanda
19955 Highland Vista Dr.
Suite 170
Ashburn, VA 20147

Date Received: 11/04/15
Date Reported: 11/05/15
Project Location: **Quantico, VA**

1. Client Sample No: **B-4** HPE Sample No.: 154920-01
Sample Matrix: Soil Date Collected: 11/04/15
Sample Location: 4.0 - 6.0 ft

Test(s) Requested: **Soil Corrosion Potential Profile**
Analysis Method(s): Various

Date Analyzed: 11/04/15

<u>Analyte</u>	<u>Result</u>	<u>Units</u>	<u>Reporting Limit</u>	<u>Qualifier</u>
Resistivity - ASTM G187	6900	ohm-cm	N/A	
Redox Potential - Electrode	+ 385	mV	N/A	
pH - CA643	5.1	pH	N/A	
Chloride (Water Soluble) - CA422	2.8	mg/Kg	2.5	
Sulfate (Water Soluble) - CA417	25	mg/Kg	5.0	
Sulfide (Water Soluble) EPA 376.2	< 1.2	mg/Kg	1.2	U
Moisture (Percent)	23	%	N/A	

JP

11/05/15

Approved by

Date

Analyte Qualifier Codes

U = Analyte was not detected

Appendix C

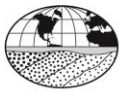
Engineering Calculations

Bearing Capacity of Square Foundation (1 page)

Bearing Capacity of Mat Foundation (1 page)

Pedestrian Bridge - Spread Footing (3 ksf) Settlement (8 pages)

Pedestrian Bridge - Mat Foundation (2.5 ksf) Settlement (9 pages)



Bearing Capacity of Square Foundation
(Classical Bearing Capacity Equation)
(Terzaghi's Equation)

Project Name: Arkendale-Powells Creek Third Track Project	Project Engineer: SU
	Principal Engineer: PB
Project Location: Prince William County	Date: March 2016
Location(s): Square Footings	

Input

Unit Weight of Foundation Soils, γ =	<input type="text" value="120"/>	lb/ft ³
Friction Angle of Foundation Soils, ϕ =	<input type="text" value="30"/>	Degrees
Cohesion of Foundation Soils, C =	<input type="text" value="0"/>	lb/ft ²
Foundation Depth, D_f =	<input type="text" value="3"/>	ft
Foundation Width, B =	<input type="text" value="6"/>	ft
Min. Safety Factor, FS =	<input type="text" value="3"/>	

$$Q_{ult} = 1.3 C N_c + q N_q + 0.4 B \gamma N_g \quad \text{Eq-3.7}$$

$$Q_{all} = Q_{ult} / FS$$

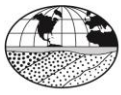
$$\begin{aligned} N_c &= 30.14 \\ N_q &= 18.40 \\ N_g &= 22.40 \\ Q_{ult} &= 13.08 \text{ KSF} \end{aligned}$$



Table 3.4: Bearing Capacity Factor

$$Q_{all} = 4.36 \text{ KSF}$$

Recommended Allowable Bearing Capacity (Q_{all}) = 3.0 KSF



Bearing Capacity of Mat Foundation
(Classical Bearing Capacity Equation)
(Terzaghi's Equation)

Project Name: Arkendale-Powells Creek Third Track Project	Project Engineer: SU
	Principal Engineer: PB
Project Location: Prince William County	Date: March 2016
Location(s): Mat Foundation	

Input

Unit Weight of Foundation Soils, γ =	<input type="text" value="120"/>	lb/ft ³
Friction Angle of Foundation Soils, ϕ =	<input type="text" value="30"/>	Degrees
Cohesion of Foundation Soils, C =	<input type="text" value="0"/>	lb/ft ²
Foundation Depth, D_f =	<input type="text" value="3"/>	ft
Foundation Width, B =	<input type="text" value="21.6"/>	ft
Min. Safety Factor, FS =	<input type="text" value="3"/>	

$$Q_{ult} = 1.3 C N_c + q N_q + 0.4 B \gamma N_g \quad \text{Eq-3.7}$$

$$Q_{all} = Q_{ult} / FS$$

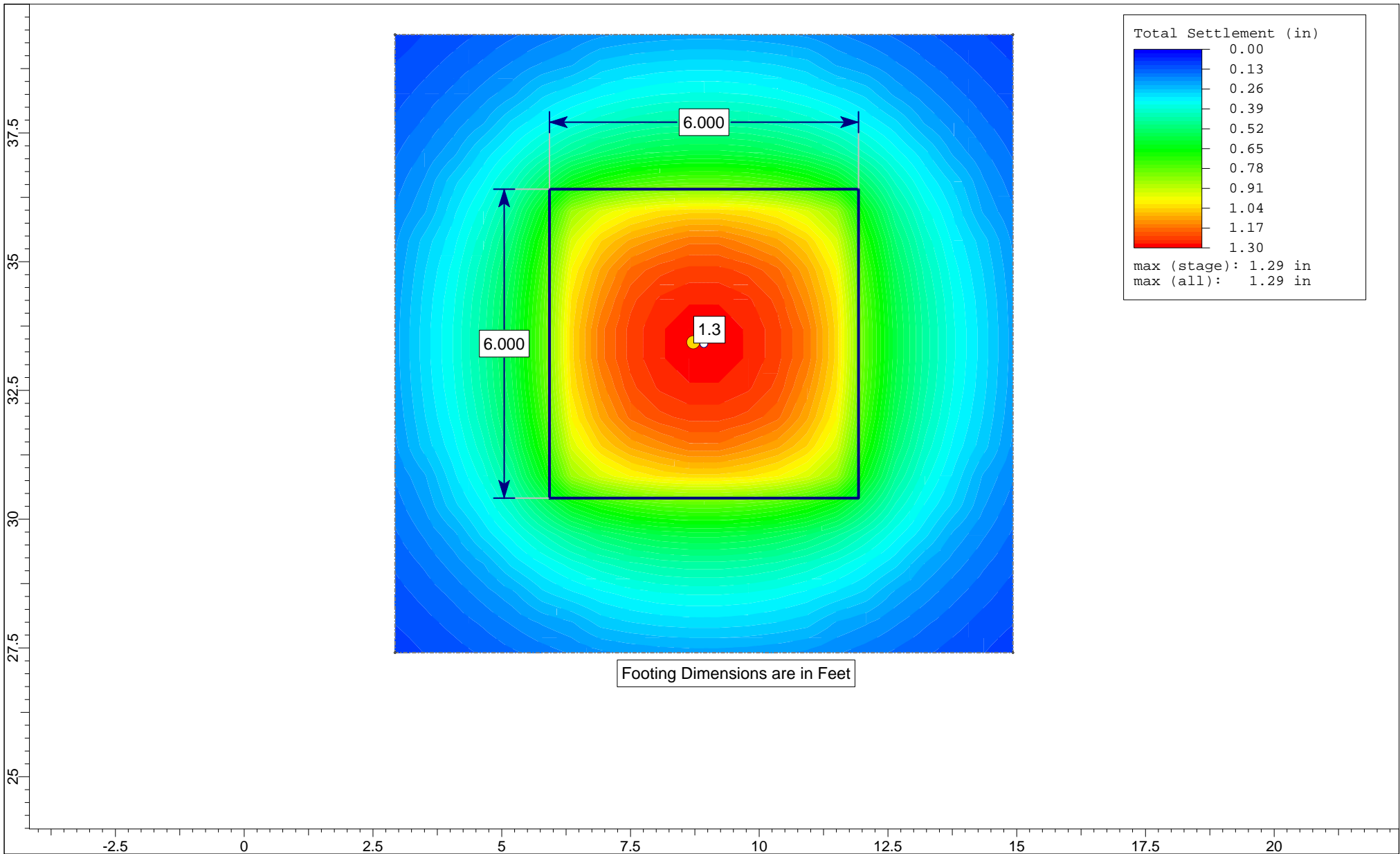
$$\begin{aligned} N_c &= 30.14 \\ N_q &= 18.40 \\ N_g &= 22.40 \\ Q_{ult} &= 29.85 \text{ KSF} \end{aligned}$$



Table 3.4: Bearing Capacity Factor

$$Q_{all} = 9.95 \text{ KSF}$$

Recommended Allowable Bearing Capacity (Q_{all}) = 2.5 KSF based on Settlement Calculations



Project	Arkendale-Powells Creek Third Track Project		
Analysis Description	Pedestrian Bridge - Spread Footing (3 ksf) Settlement		
Drawn By	Sushant Upadhyaya	Company	GeoConcepts Engineering, Inc.
Date	12/3/2015, 5:51:03 PM	File Name	Spread Footing_03-28-2016.s3z

Settle3D Analysis Information

Arkendale-Powells Creek Third Track Project

Project Settings

Document Name	Spread Footing_03-28-2016
Project Title	Arkendale-Powells Creek Third Track Project
Analysis	Pedestrian Bridge - Spread Footing (3 ksf) Settlement
Author	Sushant Upadhyaya
Company	GeoConcepts Engineering, Inc.
Date Created	12/3/2015, 5:51:03 PM

Comments

Soil Test Boring B-5	
Stress Computation Method	Westergaard
Time-dependent Consolidation Analysis	
Time Units	months
Permeability Units	feet/day
Include buoyancy effect when material settles below water table	
Include vertical stress reduction due to settlement above a point	
Use settlement cutoff	
Load/Insitu vertical stress ratio	0.1
Use average properties to calculate layered stresses	

Stage Settings

Stage #	Name	Time [months]
1	Initial	0
2	1 moth	1
3	3 months	3
4	1/2 year	6
5	1 year	12
6	1.5 year	18
7	2.5 years	30

Results

Time taken to compute: 1.09782 seconds

Stage: Initial = 0 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.817454
Consolidation Settlement [in]	-0.0016442	0
Immediate Settlement [in]	0	0.819099
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	3
Effective Stress [ksf]	0	4.19838
Total Stress [ksf]	0	7.8911
Total Strain	0	0.0144131
Pore Water Pressure [ksf]	0	3.69272
Excess Pore Water Pressure [ksf]	0	3
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	2.8	4.19715
Over-consolidation Ratio	1	123.391
Void Ratio	0	0.651
Permeability [ft/d]	0	0.10074
Coefficient of Consolidation [ft ² /d]	0	0.47
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	10
Undrained Shear Strength	0	0.83968

Stage: 1 moth = 1 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.2808
Consolidation Settlement [in]	0	0.461706
Immediate Settlement [in]	0	0.819099
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	3
Effective Stress [ksf]	0	4.20948
Total Stress [ksf]	0	7.89108
Total Strain	0	0.0301765
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.0841636
Degree of Consolidation [%]	0	98.7652
Pre-consolidation Stress [ksf]	2.8	4.20824
Over-consolidation Ratio	1	102.49
Void Ratio	0	0.651
Permeability [ft/d]	0	0.10074
Coefficient of Consolidation [ft ² /d]	0	0.47
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	99.6788
Undrained Shear Strength	0	0.840125

Stage: 3 months = 3 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.29075
Consolidation Settlement [in]	0	0.471647
Immediate Settlement [in]	0	0.819099
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	3
Effective Stress [ksf]	0	4.20948
Total Stress [ksf]	0	7.89108
Total Strain	0	0.0301766
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.0260812
Degree of Consolidation [%]	0	99.9921
Pre-consolidation Stress [ksf]	2.8	4.20824
Over-consolidation Ratio	1	102.455
Void Ratio	0	0.651
Permeability [ft/d]	0	0.10074
Coefficient of Consolidation [ft ² /d]	0	0.47
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	0.840125

Stage: 1/2 year = 6 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.29218
Consolidation Settlement [in]	0	0.473082
Immediate Settlement [in]	0	0.819099
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	3
Effective Stress [ksf]	0	4.20948
Total Stress [ksf]	0	7.89108
Total Strain	0	0.0301766
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.00447288
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	2.8	4.20824
Over-consolidation Ratio	1	102.455
Void Ratio	0	0.651
Permeability [ft/d]	0	0.10074
Coefficient of Consolidation [ft ² /d]	0	0.47
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	0.840125

Stage: 1 year = 12 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.29246
Consolidation Settlement [in]	0	0.473362
Immediate Settlement [in]	0	0.819099
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	3
Effective Stress [ksf]	0	4.20948
Total Stress [ksf]	0	7.89108
Total Strain	0	0.0301766
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.000131189
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	2.8	4.20824
Over-consolidation Ratio	1	102.455
Void Ratio	0	0.651
Permeability [ft/d]	0	0.10074
Coefficient of Consolidation [ft ² /d]	0	0.47
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	0.840125

Stage: 1.5 year = 18 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.29247
Consolidation Settlement [in]	0	0.47337
Immediate Settlement [in]	0	0.819099
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	3
Effective Stress [ksf]	0	4.20948
Total Stress [ksf]	0	7.89108
Total Strain	0	0.0301766
Pore Water Pressure [ksf]	-3.94936e-020	3.6816
Excess Pore Water Pressure [ksf]	-3.94936e-020	3.83546e-006
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	2.8	4.20824
Over-consolidation Ratio	1	102.455
Void Ratio	0	0.651
Permeability [ft/d]	0	0.10074
Coefficient of Consolidation [ft ² /d]	0	0.47
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	0.840125

Stage: 2.5 years = 30 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	1.29247
Consolidation Settlement [in]	0	0.47337
Immediate Settlement [in]	0	0.819099
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	3
Effective Stress [ksf]	0	4.20948
Total Stress [ksf]	0	7.89108
Total Strain	0	0.0301766
Pore Water Pressure [ksf]	-3.4818e-020	3.6816
Excess Pore Water Pressure [ksf]	-3.4818e-020	3.19791e-009
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	2.8	4.20824
Over-consolidation Ratio	1	102.455
Void Ratio	0	0.651
Permeability [ft/d]	0	0.10074
Coefficient of Consolidation [ft^2/d]	0	0.47
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	100
Undrained Shear Strength	0	0.840125

Loads

1. Rectangular Load

Length	6 ft
Width	6 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	36 ft ²
Load	3 ksf
Depth	0 ft
Installation Stage	Initial = 0 mon

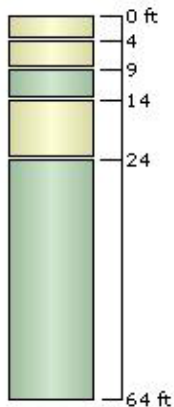
Coordinates

X [ft]	Y [ft]
5.927	30.408
11.927	30.408
11.927	36.408
5.927	36.408



Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Lean Clay (CL)	4	0	Yes
2	Lean Clay (CL)	5	4	Yes
3	Clayey Sand (SC)	5	9	Yes
4	Lean Clay (CL)	10	14	Yes
5	Clayey Sand (SC)	40	24	Yes



Soil Properties

Property	Lean Clay (CL)	Clayey Sand (SC)
Color		
Unit Weight [kips/ft ³]	0.115	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125
Immediate Settlement	Enabled	Enabled
Es [ksf]	200	300
E _{sur} [ksf]	800	1200
Primary Consolidation	Enabled	Disabled
Material Type	Non-Linear	
C _c	0.3	
C _r	0.01	
e ₀	0.651	
P _c [ksf]	2.8	2.8
C _v [ft ² /d]	0.47	
B-bar	1	
Undrained Su A [kips/ft ²]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	4	4

Groundwater

Groundwater method Piezometric Lines
 Water Unit Weight 0.0624 kips/ft³
 Generating excess pore pressure above water table

Piezometric Line Entities

ID	Depth (ft)
1	8 ft
2	8 ft
3	8 ft
4	5 ft

Query Points

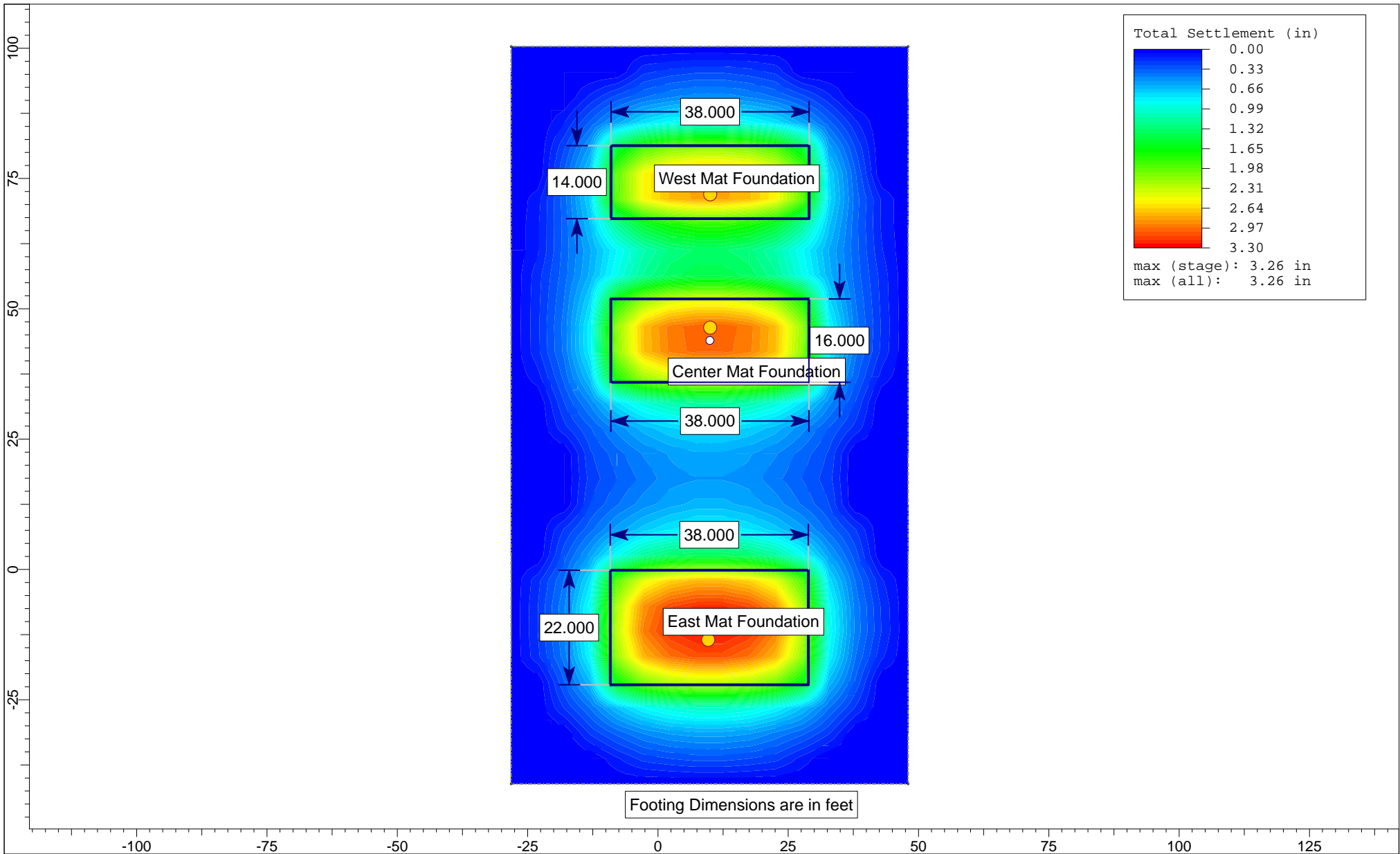
Point #	(X,Y) Location	Number of Divisions
1	8.719, 33.434	Auto: 65

Field Point Grid

Number of points 484
 Expansion Factor 2

Grid Coordinates

X [ft]	Y [ft]
14.927	39.408
14.927	27.408
2.927	27.408
2.927	39.408



Project	Arkendale-Powells Creek Third Track Project		
Analysis Description	Pedestrian Bridge - Mat Foundation (2.5 ksf) Settlement		
Drawn By	Sushant Upadhyaya	Company	GeoConcepts Engineering
Date	12/3/2015, 5:51:03 PM	File Name	Mat Foundation Based on B5.s3z

Settle3D Analysis Information

Arkendale-Powells Creek Third Track Project

Project Settings

Document Name	Mat Foundation Based on B5
Project Title	Arkendale-Powells Creek Third Track Project
Analysis	Pedestrian Bridge - Mat Foundation (2.5 ksf) Settlement
Author	Sushant Upadhyaya
Company	GeoConcepts Engineering
Date Created	12/3/2015, 5:51:03 PM

Comments

Soil Test Boring - B-5	
Stress Computation Method	Westergaard
Time-dependent Consolidation Analysis	
Time Units	months
Permeability Units	feet/day
Include buoyancy effect when material settles below water table	
Include vertical stress reduction due to settlement above a point	
Use settlement cutoff	
Load/Insitu vertical stress ratio	0.1
Use average properties to calculate layered stresses	

Stage Settings

Stage #	Name	Time [months]
1	Initial	0
2	1 moth	1
3	3 months	3
4	1/2 year	6
5	1 year	12
6	1.5 year	18
7	2.5 years	30

Results

Time taken to compute: 0 seconds

Stage: Initial = 0 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	2.53532
Consolidation Settlement [in]	-0.0069644	0
Immediate Settlement [in]	0	2.54228
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	2.5
Effective Stress [ksf]	0	4.1984
Total Stress [ksf]	0	8.12429
Total Strain	0	0.01234
Pore Water Pressure [ksf]	0	3.92795
Excess Pore Water Pressure [ksf]	0	2.5
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.8367	4.19715
Over-consolidation Ratio	1	98.5861
Void Ratio	0	0.651
Permeability [ft/d]	0	0.000571573
Coefficient of Consolidation [ft ² /d]	0	0.1
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.83968

Stage: 1 moth = 1 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.02784
Consolidation Settlement [in]	0	0.485556
Immediate Settlement [in]	0	2.54228
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	2.5
Effective Stress [ksf]	0	4.44232
Total Stress [ksf]	0	8.12392
Total Strain	0	0.0240985
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	1.60897
Degree of Consolidation [%]	0	96.909
Pre-consolidation Stress [ksf]	0.857495	4.44137
Over-consolidation Ratio	1	95.7494
Void Ratio	0	0.651
Permeability [ft/d]	0	0.000571573
Coefficient of Consolidation [ft ² /d]	0	0.1
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.84931

Stage: 3 months = 3 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.17697
Consolidation Settlement [in]	0	0.634689
Immediate Settlement [in]	0	2.54228
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	2.5
Effective Stress [ksf]	0	4.4422
Total Stress [ksf]	0	8.1238
Total Strain	0	0.0241151
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.588402
Degree of Consolidation [%]	0	98.627
Pre-consolidation Stress [ksf]	0.857495	4.44137
Over-consolidation Ratio	1	95.6078
Void Ratio	0	0.651
Permeability [ft/d]	0	0.000571573
Coefficient of Consolidation [ft ² /d]	0	0.1
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.84931

Stage: 1/2 year = 6 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.23674
Consolidation Settlement [in]	0	0.69446
Immediate Settlement [in]	0	2.54228
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	2.5
Effective Stress [ksf]	0	4.44215
Total Stress [ksf]	0	8.12375
Total Strain	0	0.0241198
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.214497
Degree of Consolidation [%]	0	99.4353
Pre-consolidation Stress [ksf]	0.857495	4.44137
Over-consolidation Ratio	1	95.5409
Void Ratio	0	0.651
Permeability [ft/d]	0	0.000571573
Coefficient of Consolidation [ft ² /d]	0	0.1
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.84931

Stage: 1 year = 12 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.25869
Consolidation Settlement [in]	0	0.716412
Immediate Settlement [in]	0	2.54228
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	2.5
Effective Stress [ksf]	0	4.44213
Total Stress [ksf]	0	8.12373
Total Strain	0	0.0241209
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.0367872
Degree of Consolidation [%]	0	99.9032
Pre-consolidation Stress [ksf]	0.857495	4.44137
Over-consolidation Ratio	1	95.5243
Void Ratio	0	0.651
Permeability [ft/d]	0	0.000571573
Coefficient of Consolidation [ft ² /d]	0	0.1
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.84931

Stage: 1.5 year = 18 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.26142
Consolidation Settlement [in]	0	0.719144
Immediate Settlement [in]	0	2.54228
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	2.5
Effective Stress [ksf]	0	4.44213
Total Stress [ksf]	0	8.12373
Total Strain	0	0.024121
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.00630526
Degree of Consolidation [%]	0	99.9834
Pre-consolidation Stress [ksf]	0.857495	4.44137
Over-consolidation Ratio	1	95.5236
Void Ratio	0	0.651
Permeability [ft/d]	0	0.000571573
Coefficient of Consolidation [ft ² /d]	0	0.1
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.84931

Stage: 2.5 years = 30 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	3.26192
Consolidation Settlement [in]	0	0.719643
Immediate Settlement [in]	0	2.54228
Secondary Settlement [in]	0	0
Loading Stress [ksf]	0	2.5
Effective Stress [ksf]	0	4.44213
Total Stress [ksf]	0	8.12373
Total Strain	0	0.024121
Pore Water Pressure [ksf]	0	3.6816
Excess Pore Water Pressure [ksf]	0	0.000184574
Degree of Consolidation [%]	0	99.9995
Pre-consolidation Stress [ksf]	0.857495	4.44137
Over-consolidation Ratio	1	95.5236
Void Ratio	0	0.651
Permeability [ft/d]	0	0.000571573
Coefficient of Consolidation [ft ² /d]	0	0.1
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0.84931

Loads

1. Rectangular Load

Length 38 ft
 Width 22 ft
 Rotation angle 0 degrees
 Load Type Flexible
 Area of Load 836 ft²
 Load 2.5 ksf
 Depth 0 ft
 Installation Stage Initial = 0 mon

Coordinates

X [ft]	Y [ft]
-9.147	-22.14
28.853	-22.14
28.853	-0.14
-9.147	-0.14

2. Rectangular Load

Length 38 ft
 Width 16 ft
 Rotation angle 0 degrees
 Load Type Flexible
 Area of Load 608 ft²
 Load 2.5 ksf
 Depth 0 ft
 Installation Stage Initial = 0 mon

Coordinates

X [ft]	Y [ft]
-9.038	35.904
28.962	35.904
28.962	51.904
-9.038	51.904

3. Rectangular Load

Length 38 ft
 Width 14 ft
 Rotation angle 0 degrees
 Load Type Flexible
 Area of Load 532 ft²
 Load 2.5 ksf
 Depth 0 ft
 Installation Stage Initial = 0 mon

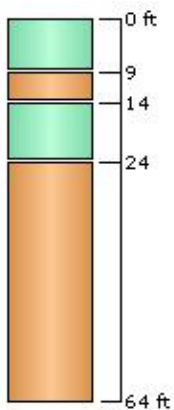
Coordinates

X [ft]	Y [ft]
-9.005	67.302
28.995	67.302
28.995	81.302
-9.005	81.302



Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Lean Clay (CL)	9	0	Yes
2	Clayey Sand (SC)	5	9	Yes
3	Lean Clay (CL)	10	14	Yes
4	Clayey Sand (SC)	40	24	Yes



Soil Properties

Property	Lean Clay (CL)	Clayey Sand (SC)
Color		
Unit Weight [kips/ft ³]	0.115	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125
Immediate Settlement	Enabled	Enabled
Es [ksf]	200	300
Esur [ksf]	800	1200
Primary Consolidation	Enabled	Disabled
Material Type	Non-Linear	
Cc	0.3	
Cr	0.01	
e0	0.651	
Pc [ksf]	2.8	
OCR		1
Cv [ft ² /d]	0.47	
B-bar	1	
Undrained Su A [kips/ft ²]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	4	4

Groundwater

Groundwater method Piezometric Lines
 Water Unit Weight 0.0624 kips/ft³
 Generating excess pore pressure above water table

Piezometric Line Entities

ID	Depth (ft)
1	8 ft
2	8 ft
3	8 ft
4	5 ft

Query Points

Point #	(X,Y) Location	Number of Divisions
1	10.03, 71.944	Auto: 59
2	10.03, 46.384	Auto: 59
3	9.656, -13.504	Auto: 59

Field Point Grid

Number of points 480
 Expansion Factor 2

Grid Coordinates

X [ft]	Y [ft]
47.995	100.302
47.995	-41.14
-28.147	-41.14
-28.147	100.302



APPENDIX D

GEOTECHNICAL REPORT

RETAINING WALL NO. 13

Note: The requirements of this Appendix are applicable to the Contractor's "Means and Methods" for planning, submissions, approvals and execution of the work.

Measurement and Payment for items as required will be included in other pay items. See PAY ITEM DESCRIPTION & ESTIMATED QUANTITIY SUMMARY of the plans.

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APPENDIX D
GEOTECHNICAL REPORT
RETAINING WALL NO. 13

Note: The Geotechnical Report is provided for Information Only. The Report was prepared solely for the use of VRE/DRPT in establishing design controls for the project.

The Report is made available to bidders in order that they may have access to design data identical to that which is possessed by VRE/DRPT and is not intended as a substitute for personal investigation, interpretation and judgement by the bidders.

June 9, 2020

Revision 1

Geotechnical Engineering Report

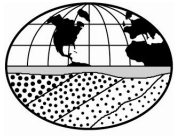
**Retaining Wall No. 13
Arkendale to Powells Creek
Third Track Project
Prince William County, Virginia**



**GeoConcepts
Engineering, Inc.**

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June 9, 2020
Revision 1

Mr. Ronald C. Briggs, PE
STV, Inc.
10800 Midlothian Turnpike, Suite 302
Richmond, Virginia 23235

Subject: Geotechnical Engineering Report, Retaining Wall No. 13,
Arkendale to Powells Creek Third Track Project, Prince
William County, Virginia (Our JD205150)

Dear Mr. Briggs:

GeoConcepts Engineering, Inc. (GeoConcepts) is pleased to present the following geotechnical engineering report prepared for Retaining Wall No. 13 at the Arkendale to Powells Creek Third Track Project in Prince William County, Virginia. This report has been revised to incorporate owner's comment on the previous report dated May 12, 2016.

We appreciate the opportunity to serve as your geotechnical consultant on this project. Please do not hesitate to contact me if you have any questions or want to meet to discuss the findings and recommendations contained in the report.

Sincerely,

GEOCONCEPTS ENGINEERING, INC.

Sushant Upadhyaya, PhD, PE, PMP
Principal
Sushant.upadhyaya@terracon.com

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Figure 1: Site Vicinity Map

Appendix A: Subsurface Investigation
Appendix B: Soil Laboratory Test Results
Appendix C: Global Stability Results
Appendix D: Lateral Capacity Analysis
Appendix E: Wall Cross-Sections

1.0 Scope of Services

This geotechnical engineering report presents the results of the field investigation, soil laboratory testing, and engineering analysis of the geotechnical data. This report specifically addresses the following:

- An evaluation of subsurface conditions within the area of the proposed retaining wall, including a metal corrosion and concrete attack potential of on-site soils.
- Soil design parameters for use in design of the proposed retaining wall.
- Global stability analysis of the proposed retaining wall, including recommendations to enhance stability as applicable.
- Lateral capacity analysis of proposed soldier piles.
- Earthwork recommendations for construction of loadbearing fills, including an assessment of on-site soils to be excavated for re-use as fill.

Services not specifically identified in the contract for this project are not included in the scope of services.

2.0 Site Description and Proposed Construction

The site is located northwest of the intersection of Potomac Avenue and C Street in Quantico, Prince William County, Virginia. A site vicinity map is presented as Figure 1 at the end of this report. The proposed retaining wall No. 13 site is located on the west side of the CSX railroad and is occupied by an existing 1.2H:1V slope covered with wooded and grassy areas. The elevation at the bottom of the slope ranges from approximately elevation (EL) 23 to EL 30, with the top of slope reaching its maximum height at about EL 58.



Figure 2.0-1: Imagery provided by Google Maps, 2015

Based on plans provided to us by STV Incorporated dated May 1, 2020, the proposed retaining wall starts at station 8262+05 and extends through station 8269+19. Wall heights range from about 7 to 26 feet, with some locations having up to about a 10 feet high and average 2H:1V slope above the top of wall. The

wall is proposed to be constructed primarily as a soil nail wall, with a soldier pile wall planned between stations 8262+05 and 8264+16.

3.0 Subsurface Conditions

Subsurface conditions were investigated by drilling a total of four test borings in the proposed retaining wall area. We have also reviewed one previous test boring drilled by our firm in this area in 2010. In addition, a memorandum dated March 16, 2015 was prepared by RK&K subsurface studies, of which four test borings were located in the proposed retaining wall area. Although the geotechnical recommendations presented in the RK&K report do not apply to this project, the subsurface information from that study has been reviewed as a part of this project. Test boring data by others is assumed to be complete and accurate. We do not assume any responsibility for the completeness and accuracy of data obtained from others without our supervision. Test boring logs and a boring location plan are presented in Appendix A of this report.

3.1 Geology

The site is located within the Coastal Plain Physiographic Province of Virginia. The Coastal Plain consists of a seaward thickening wedge of unconsolidated to semi-consolidated sedimentary deposits from the Cretaceous Geologic Period to the Holocene Geologic Epoch. These deposits represent marginal-marine to marine sediments consisting of interbedded sands and clays. The Coastal Plain is bordered to the east by the Atlantic Ocean and to the west by the Piedmont Physiographic Province. The dividing line between the Coastal Plain and the Piedmont is locally referred to as the "Fall Line". This name comes from the waterfalls that form as a result of the differential erosion that occurs as streams cross the Piedmont/Coastal Plain contact.

Specifically, according to local geologic maps, the site is mapped in the Potomac Formation of the Cretaceous geologic period. Based on our subsurface investigation, the sediments and strata correspond favorably to the geologic publications.

The Potomac Group sediments are the oldest sedimentary deposits in the Quantico, Virginia area. These soils are known to be highly over-consolidated as a result of the weight of a substantial thickness of overlying soils that have since been eroded away. As a result of over-consolidation, Potomac Formation soils have been pre-loaded and are capable of supporting substantial loads. The Potomac Formation clays are well documented with problems associated with slope instability.

3.2 Published Soils

According to the Prince William County GIS Mapper, the site's residual soils consist of Category II and III soils. Category II soils are considered potential problem soils in Prince William County due to high groundwater tables and shallow rock and Category III soils are considered problem soils in Prince William County due to high shrink/swell potential, perennial high groundwater tables, or the existence of undocumented, uncontrolled fill, flood plain deposits, and compressible soils. A summary of soil type characteristics is provided in Table 3.2-1 and a published soil map report is presented in Appendix A of this report.

Table 3.2-1: Soil Type Characteristics by Mapping Unit

Mapping Unit	Soil Group	Slope (percent)	Hydrologic Soil Class	Drainage	Published Depth to Water Table	Published Depth to Restrictive Feature
TeA	Tetotum Fine Sandy Loam	0 to 2	C	Moderately Well-drained	18 to 30 inches	>80 inches
KfC2	Kempsville Fine Sandy Loam, Gravelly Substratum	6 to 10	A	Well-drained	>80 inches	>80 inches

3.3 Stratification

The subsurface materials encountered have been stratified for purposes of our discussions herein. These stratum designations do not imply that the materials encountered are continuous across the site. Stratum designations have been established to characterize similar subsurface conditions based on material gradations and parent geology. The generalized subsurface materials encountered in the test borings completed at the site have been assigned to the following strata:

Stratum A (Existing Fill)	loose or firm, clayey SAND (SC), and LEAN CLAY (CL) with sand, moist, brown, black, and orange
Stratum B1 (Terrace Deposits)	stiff to very stiff, LEAN CLAY (CL) and SILT (ML), with various amounts of sand, moist, white, orange, and tan
Stratum B2 (Terrace Deposits)	loose to very dense, POORLY and WELL GRADED SAND (SP/SW) and silty and clayey SAND (SM/SC), moist to wet, white, orange, and tan
Stratum C1 (Potomac Formation)	hard to very hard, FAT CLAY (CH), SILT (ML), and LEAN CLAY (CL) with various amounts of sand, moist, blue, green, and brown
Stratum C2 (Potomac Formation)	dense to very dense, clayey SAND (SC), moist, blue, green, and brown

The two letter designations included in the strata descriptions presented above and on the test boring logs represent the Unified Soil Classification System (USCS) group symbol and group name for the samples based on laboratory testing per ASTM D-2487 and visual classifications per ASTM D-2488. It should be noted that visual classifications per ASTM D-2488 may not match classifications determined by laboratory testing per ASTM D-2487.

3.4 Groundwater

Groundwater level observations were made in the field during drilling and up to three days after the completion of the test borings. Longer-term groundwater level readings were obtained from a temporary observation standpipe installed in test boring BH-01. A summary of the water level readings rounded off to the nearest 0.5 feet elevation is presented below in Table 3.4-1.

Table 3.4-1: Groundwater Summary

Test Boring No.	Approximate Ground Surface Elevation (ft)	Depth to Groundwater (ft)		Groundwater Elevation (ft)	
		First Encountered	Long-Term	First Encountered	Long-Term
BH-01	EL 42	25	18.5*	EL 17	EL 23.5*
BH-02	EL 48	34	NR	EL 14	NR
BH-03	EL 57	33	NR	EL 24	NR
BH-04	EL 43	24	NR	EL 19	NR

NR: not recorded * Groundwater reading was taken after 72 hours in the temporary standpipe.

As shown in the table above, groundwater was encountered at depths of about 18 to 34 feet below the existing ground surface, with long term measurements indicating groundwater level at about EL 23.5. Therefore, it is recommended that a groundwater level at EL 23.5 be used for design.

The groundwater observations presented herein are considered to be an indication of the groundwater levels at the dates and times indicated. Where more impervious Strata B1 and C1 fine-grained soils are encountered, the amount of water seepage into the borings is limited, and it is generally not possible to establish the location of the groundwater table through short term water level observations. Accordingly, the groundwater information presented herein should be used with caution. Also, fluctuations in groundwater levels should be expected with seasons of the year, construction activity, changes to surface grades, precipitation, or other similar factors.

3.5 Soil Laboratory Test Results

Selected soil samples obtained from the field investigation were tested for grain size distribution, Atterberg limits, shear strength, and natural moisture content. Laboratory test results are presented in Appendix B of this report and are summarized below.

3.5.1 Classification Test Results

A summary of soil classification test results is presented below in Table 3.5.1-1, and the results of natural moisture content tests are presented on the test boring logs in Appendix A.

Table 3.5.1-1: Summary of Soil Classification Test Results

Test Boring No.	Depth (ft)	Sample Type	Stratum	Description of Soil Specimen	Sieve Results		Atterberg Limits			Natural Moisture Content (%)
					Percent Retained #4 Sieve	Percent Passing #200 Sieve	LL	PL	PI	
BH-01	6.0-8.0	Split-Spoon	B1	clayey SAND (SC)	10.2	18.7	29	20	9	10.9
BH-02	14.0-16.0	Shelby Tube	B2	POORLY GRADED SAND with silt (SP-SM)	0.6	8.3	NP	NP	NP	4.7
BH-02	48.5-50.0	Split-Spoon	C2	clayey SAND (SC)	11.4	26.9	58	29	29	24.2
BH-03	13.5-15.0	Split-Spoon	B1	LEAN CLAY (CL)	0.0	86.8	37	21	16	17.1
BH-03	18.5-20.0	Split-Spoon	B1	LEAN CLAY with sand (CL)	0.4	80.7	27	18	9	18.0
BH-04	23.5-25.0	Split-Spoon	C1	FAT CLAY (CH)	0.0	91.5	72	21	51	28.1
BH-04	28.0-30.0	Shelby Tube	C1	FAT CLAY (CH)	0.0	86.6	50	25	25	24.3
BH-04	33.5-35.0	Split-Spoon	C1	LEAN CLAY with sand (CL)	0.0	80.7	46	24	22	30.6
BH-04	53.5-55.0	Split-Spoon	C1	SILT with sand (ML)	0.4	77.9	45	30	15	23.1

Notes:

1. Soil tests are in accordance with applicable ASTM standards
2. Soil classification symbols are in accordance with Unified Soil Classification System
3. Key to abbreviations: LL = liquid limit; PL = plastic limit; PI = plasticity index; NP = nonplastic; N/T = not tested

3.5.2 Direct Shear Test Results

One direct shear test was performed under consolidated drained conditions on an undisturbed tube sample of the Stratum B2 soils. The results of the direct shear tests are presented below in Table 3.5.2-1.

Table 3.5.2-1: Direct Shear Test Results

Test Boring No.	Sample Depth (ft)	USCS Symbol	Effective Angle of Internal Friction f' (degrees)	Effective Cohesion c' (psf)
BH-02	14.0-16.0	SP-SM	36.9	101

3.5.3 Consolidated Undrained Triaxial Test Results

One consolidated undrained (CU) triaxial test (ASTM D4767) was performed on an undisturbed tube sample of the Stratum B1 soils. The results of the triaxial test are presented below in Table 3.5.3-1.

Table 3.5.3-1: Consolidated Undrained Triaxial Test Results

Test Boring No.	Sample Depth (ft)	USCS Symbol	Effective Shear Strength Parameters		Total Shear Strength Parameters	
			Angle of Internal Friction, f' (deg)	Cohesion, c' (psf)	Angle of Internal Friction, f (deg)	Cohesion, c (psf)
BH-02	28.0-30.0	CH	6.2	888	2.7	1,040

3.5.4 Corrosion Test Results

In addition to standard geotechnical soil laboratory testing, one soil sample was submitted to an analytical laboratory for metal corrosion and concrete attack testing. Corrosion testing consisted of analysis for moisture content (ASTM D-2216), pH (CA 643), resistivity (ASTM G187), sulfides (EPA 376.2), reduction-oxidation potential (electrode), Sulfate (CA Test 417) and chloride (CA 422). The results of these tests are presented below in Table 3.5.4-1.

Table 3.5.4-1: Metal Corrosion Test Results

Test Boring No.	Sample Depth (ft)	Moisture Content (%)	pH	Resistivity (ohm – cm)	Sulfides (ppm)	Red-ox Potential (mV)	Sulfate Concentration (ppm)	Chloride (ppm)
BH-01	15.0-20.0	17.0	4.7	12,000	<1.2	+ 362	<5.0	6.8

* ppm = parts per million

3.6 Seismic Site Classification

We have evaluated the Soil Profile Type and Site Coefficient for this project according to the 2012 International Building Code (IBC). Based on the results of the current and previous subsurface investigation and our knowledge of local geologic conditions, the site soils have been assigned to a site class D.

The site coefficients and adjusted Maximum Considered Earthquake (MCE) spectral response acceleration parameters were obtained from the United States Geological Survey (USGS) website and are presented below in Table 3.6-1.

Table 3.6-1: Site Coefficients and Adjusted MCE Spectral Response Acceleration per IBC

Mapped Spectral Accelerations for Site Class D and 5% Damping (Step 1)	Site Coefficients to Modify Accelerations Based on Site Classification D (Step 2)
$S_s = 0.127 \text{ g}$	$F_a = 1.6$
$S_1 = 0.053 \text{ g}$	$F_v = 2.4$

MCE Spectral Response Accelerations (Step 3)	Design Spectral Response Accelerations (Step 4)
$S_{MS} = 0.204 \text{ g}$	$S_{DS} = 0.136 \text{ g}$
$S_{M1} = 0.126 \text{ g}$	$S_{D1} = 0.084 \text{ g}$

4.0 Engineering Analysis

Recommendations regarding soil design parameters, corrosion considerations, global stability, lateral capacity, and earthwork are presented herein.

4.1 Soil Design Parameters

We understand that the proposed retaining wall starts approximately at station 8262+05 and extends through station 8269+19. Wall heights range from about 7 to 26 feet, with some locations having up to about 10 feet high and average 2H:1V slope above the top of wall. We also understand that the wall is proposed to be constructed primarily as a soil nail wall, with a soldier pile wall planned between stations 8262+05 and 8264+16.

Soil strength parameters recommended for use in the retaining wall design are presented in Table C-1 in Appendix C and are based on soil laboratory testing and our experience with similar soil materials and geologic conditions.

The project is mapped through a number of geologic formations, including those described as Potomac Formation. The high-plasticity Potomac Formation fine-grained soils can present stability issues over extended periods of time due to the potential for softening and weakening along the existing fissures in the clay/silt, resulting from exposure of the fissures to disturbance and water from construction activities. The clay/silts often exhibit slickensides (previously sheared surfaces characterized by residual shear strengths) along the fissures and discontinuities that may impact their overall stability. Note that in determining the shear strength design parameters for the Potomac Formation Fine-Grained soils, the structure as well as the analysis type are the most important considerations. In the global stability analysis, soils determined to be "high plastic" were assigned residual friction angle, and soils determined to be "low plastic" were assigned fully softened friction angle. In the lateral resistance analysis for soldier piles, fully softened friction angle would be used for both "high plastic" and "low plastic" clays. However, fine-grained Potomac Formation soil was not encountered along the soldier pile section of the wall.

The residual and fully softened shear strengths were evaluated from laboratory tests such as direct shear tests and consolidated undrained triaxial tests, and from published correlations of Liquid Limit, Plasticity Index, and clay fraction. Based on correlations provided by Stark and Hussain (2012) we estimated that the fully softened friction angle for low plasticity Potomac Formation clay encountered in test boring BH-03 between elevation (EL) 18 and EL -1.5 varies between 29 degrees at the top of the layer and 23 degrees at the bottom of the layer. Therefore, the friction angle used in the long-term global stability analyses for Sections D-D and E-E between EL 18 and EL -1.5 varies accordingly using a Spatial Mohr-Coulomb material model. The calculated residual friction angle of 13 degrees is used below EL -1.5. In test boring BH-04, used in the global stability analysis for Section F-F, low plasticity Potomac Formation clay was encountered below approximately EL 10. A uniform friction angle of 23 degrees is applied for this material in the long-term condition. The residual friction angle of 13 degrees is used for high plasticity Potomac Formation clay encountered above, between approximately EL 20 and EL 10.

4.2 Corrosion Potential

The test results presented in Table 3.5.4-1 were evaluated to determine the corrosion potential of the soil nail and soldier pile walls. The potential corrosion of the soil nail walls was evaluated based on Section 3.9 and Appendix C of FHWA-NHI-14-007 Soil Nail Walls Reference Manual, and for soldier piles were evaluated based on Section 8.8 of FHWA NHI-05-042, Design and Construction of Driven Pile Foundations – Volume I.

Based on the evaluation criteria presented in above references, soils with a $pH < 5.5$ are considered to have mild to no corrosion potential. Therefore, we recommend protective measures which can reduce corrosion such as increased concrete cover around the reinforcing steel, and the use of galvanized, or epoxy coated reinforcement.

4.3 Global Stability Analysis

An analysis of six retaining wall sections, designated Sections A-A' to F-F', has been completed to evaluate global stability. The critical sections analyzed are as shown on the boring location plan, Figure A-1 in Appendix A. Global stability analysis was performed using the limit equilibrium slope stability program Slope-W developed by Geo-Slope International. This computer program has been used to generate potential failure surfaces with randomly selected radii and centers. The stability analysis was performed for both undrained and drained soil conditions, and assumes static loading. A surcharge load of 250 psf was applied at the top of the retaining wall. A search for the most critical potential failure surfaces occurring within earth materials in the proposed slopes were performed using circular failure modes as calculated by the Morgenstern-Price method. A minimum factor of safety equal or above 1.5 is considered satisfactory for long-term stability of the walls. A minimum factor of safety equal or above 1.3 is considered satisfactory for short-term stability of the walls. Global stability results are included in Appendix C and are summarized below in Table 4.3-1.

Table 4.3-1: Summary of Global Stability Analysis

Cross-Section	Applicable Station Range	Station No. Analyzed	Approximate Wall Height (ft)	Factor of Safety		Remarks*
				Short Term	Long Term	
A-A' (soldier pile wall)	8262+00 to 8264+16	8263+00	10	1.5	1.5	See Section 4.4 for the requirements of the soldier piles
		8264+00	12			
B-B' (soil nail wall)	8264+16 to 8265+50	8265+50	19	2.3	2.1	Minimum soil nail length required 18 ft.
C-C' (soil nail wall)	8265+50 to 8266+50	8266+00	22	2.4	2.2	Minimum soil nail length required 20 ft.
D-D' (soil nail wall)	8266+50 to 8267+50	8267+00	23	1.5	1.5	Minimum soil nail length required 30 ft.
E-E' (soil nail wall)	8267+50 to 8268+50	8267+50	23	1.5	1.5	Minimum soil nail length required 31 ft.
F-F' (soil nail wall)	8268+50 to 8269+19	8268+50	19	2.3	1.5	Minimum soil nail length required 30 ft.

*Soil nails measured 15 degrees from horizontal with the minimum length shown are required. The specialty contractor should design the soils nails with minimum length and spacing requirements described in the text of the report.

The above calculated factor of safeties for Sections B-B' through F-F' assume a maximum soil nail spacing (horizontal and vertical) of 5 feet for wall heights less than 18 feet, and a maximum soil nail spacing (horizontal and Vertical) of 4 feet for wall heights greater than 18 feet. In addition, where applicable, grouted soil nail anchors are a minimum of 6 inches in diameter. The minimum lengths for the soil nails are provided in Table 4.3-1. The final design of the soil nail walls is the responsibility of the soil nail wall designer.

We recommend that the retaining wall for this project be provided with a drainage system to prevent buildup of hydrostatic pressures behind the wall. As part of the drainage control for the retaining wall, all proposed or existing slopes above and below the retaining walls should be maintained and protected against erosion.

4.4 Lateral Capacity Analysis of Soldier Piles

We understand that the proposed soldier piles will be required to resist lateral earth pressures and global stability shear force to increase the global stability to a factor of safety of 1.5. Lateral pile capacities have been analyzed with the computer software program LPILE. Lateral capacities and deflections have been developed assuming free head conditions, active earth pressures, and a surcharge of 250 psf acting on top of the wall. Soil parameters used in the LPILE program for lateral load analyses are presented in Table C-1 in Appendix C.

Table 4.4-1 below presents the estimated pile lengths with calculated deflection and bending moment. Curves showing deflection, bending moment, and shear are included in Appendix D of this report.

Table 4.4-1: Summary of Pile Lateral Load Analysis

Station Range	Pile Size and Spacing	Pile Length (ft) / Pile Tip Elevation (ft) ¹	Calculated Maximum Shear in Pile (kips) ²	Calculated Maximum Bending Moment in Pile (kip-ft) ²	Calculated Horizontal Deflection at Pile Head (inch) ²
8262+05 to 8263+50	HP 14x73 at 6 feet O.C.	36 / EL -1.6	20	155	1.0
8263+50 to 8264+98	HP 14x73 at 6 feet O.C.	40 / EL -1.6	28*	242*	2.4*
8263+98 to 8264+16	HP 14x73 at 6 feet O.C.	41 / EL -5.6	28	242	2.4

1. Pile length and tip elevations are based on the drawing RW13-05 dated May 01, 2020.

2. *Since the conditions are similar, results from Station range 8263+98 to 8264+16 are used.

4.5 Earthwork

Fill may be required for site grading including as backfill against walls below grade. The areas to be filled should be cleared and grubbed prior to placing fill. Unsuitable existing fill, soft or loose natural soils, organic material, and rubble should be stripped to approved subgrades as determined by the geotechnical engineer. Topsoil depths presented on the boring logs should not be considered as stripping depths, as topsoil depths may vary widely across the site. Stripping depths will probably extend to greater depths than the topsoil depths indicated herein due to the presence of minor amounts of organics, roots, and other surficial materials that will require removal as a part of the stripping operations. In addition, seasonal soil moisture variations can affect stripping depths. In general, less stripping may occur during summer months when drier weather conditions can be expected. It is noted from the test borings that the upper 1 to 1.5 feet of soils are relatively soft. The depth of required stripping should be determined prior to construction by the excavation contractor using test pits, probes, or other means that the contractor wishes to employ, and this determination should be the responsibility of the excavation contractor. All subgrades should be proofrolled with a minimum 20 ton, loaded dump truck or suitable rubber tire construction equipment approved by the geotechnical engineer, prior to the placement of new fill.

There may be some areas of deeper subcutting for removal of soft wet soils, particularly along seasonal creeks or drainage channels on the site. Actual undercutting requirements may also depend on groundwater conditions in the lower elevations at the time of construction. In some cases, soil stabilization/improvement methods such as the use of geogrids/geotextiles may be an economically beneficial option to the traditional removal and replacement option.

Fill material should be placed in lifts not exceeding 8 inches loose thickness, with fill materials compacted by hand operated tampers or light compaction equipment placed in maximum 4-inch thick loose lifts. Fill

should be compacted at $\pm 2\%$ of the optimum moisture content to at least 95 percent of the maximum dry density per ASTM D-698.

Fill placed along slopes steeper than 5H:1V should be benched into the existing slope. Benches should consist of minimum 8 feet wide level cut, and at least one such bench should be used for each 3 feet of vertical rise of fill placed.

Materials used for compacted fill should consist of soils classifying SC, SM, SP, SW, GC, GM, GP, or GW per ASTM D-2487, with a liquid limit and plasticity index less than 40 and 15, respectively. It is expected that portions of soils excavated at the site will be suitable for re-use as fill based on classification. In addition, the Stratum A existing fill may not be suitable for re-use as new compacted fill due to deleterious man-made materials in the fill. Also, drying of excavated soils by spreading and aerating may be necessary to obtain proper compaction. This may not be practical during the wet period of the year. Accordingly, earthwork operations should be planned for early Spring through late Fall, when drier weather conditions can be expected. Individual borrow areas, both from on-site and off-site sources, should be sampled and tested to verify classification of materials prior to their use as fill.

Fill materials should not be placed on frozen or frost-heaved soils, and/or soils that have been recently subjected to precipitation. All frozen or frost-heaved soils should be removed prior to continuation of fill operations. Borrow fill materials should not contain frozen materials at the time of placement.

Compaction equipment that is compatible with the soil type used for fill should be selected. Theoretically, any equipment type can be used as long as the required density is achieved; however, sheepfoot roller equipment are best suited for fine-grained soils and vibratory smooth drum rollers are best suited for granular soils. Ideally, a smooth drum roller should be used for sealing the surface soils at the end of the day or prior to upcoming rain events. In addition, compaction equipment used adjacent to walls below grade should be selected so as to not impose undesirable surcharge on walls. All areas receiving fill should be graded to facilitate positive drainage of any water associated with precipitation and surface run-off.

After completion of compacted fill operations, wall construction should begin immediately, or the finished subgrade should be protected from exposure to inclement weather conditions. Exposure to precipitation and freeze/thaw cycles will cause the finished subgrade to soften and become excessively disturbed. If development plans require that finished subgrades remain exposed to weather conditions after completion of fill operations, additional fill should be placed above finished grades to protect the newly placed fill. Alternatively, a budget should be established for reworking of the upper 1 to 2 feet of previously placed compacted fill.

4.6 References

Stark, T.D. AND Hussain M., 2012 Empirical Correlations – Drained Shear Strength For Slope Stability Analyses, ASCE Journal of Geotechnical and Environmental Engineering. Paper# GTENG-2476 – Revision No. 2.

5.0 General Limitations

Recommendations contained in this report are based upon the data obtained from the relatively limited number of test borings. This report does not reflect conditions that may occur between the points investigated, or between sampling intervals in test borings. The nature and extent of variations between test borings and sampling intervals may not become evident until the course of construction. Therefore, it is essential that on-site observations of subgrade conditions be performed during the construction period to determine if re-evaluation of the recommendations in this report must be made. It is critical to the successful completion of this project that GeoConcepts be retained during construction to observe the implementation of the recommendations provided herein.

This report has been prepared to aid in the evaluation of the site and to assist your office and the design professionals in the design of this project. It is intended for use with regard to the specific project as

described herein. Changes in proposed construction, grading plans, structural loads, etc. should be brought to our attention so that we may determine any effect on the recommendations presented herein.

An allowance should be established for additional costs that may be required for foundation and earthwork construction as recommended in this report. Additional costs may be incurred for various reasons including wet fill materials, soft subgrade conditions, unexpected groundwater problems, etc.

We recommend the project specifications contain the following statement: "A geotechnical engineering report has been prepared for this project by GeoConcepts Engineering, Inc. This report is for informational purposes only and should not be considered part of the contract documents. The opinions expressed in this report are those of the geotechnical engineer and represent their interpretation of the subsoil conditions, tests and results of analyses that they performed. Should the data contained in this report not be adequate for the contractor's purposes, the contractor may make their own investigations, tests and analyses prior to bidding."

This report was prepared in accordance with generally accepted geotechnical engineering practices. No warranties, expressed or implied, are made as to the professional services included in this report.

We appreciate the opportunity to be of service for this project. Please contact the undersigned if you require clarification of any aspect of this report.

Sincerely,

GEOCONCEPTS ENGINEERING, INC.

Alistair Garden, EIT
Staff Engineer

Sushant Upadhyaya, PhD, PE, PMP
Principal

MLS/FM/PEB/SU/shm/clm/AG/DK
\\dcmetrowest1\Data\Projects\2020\JD205150\Working Files\DRAFTS (Proposal-Reports-Communications)\Arkendale to Powell's Creek Third Track
Project GER-DK.docx

Appendix A

Subsurface Investigation

Subsurface Investigation Procedures (1 page)

Identification of Soil (1 page)

Test Boring Notes (1 page)

Test Boring Logs (8 pages)

Previous Test Boring Log by GeoConcepts (1 page)

Previous Test Boring Logs by RK&K (4 pages)

Boring Location Plan, Figure A-1 (1 page)

Soil Map (3 pages)

Subsurface Investigation Procedures

1. Test Borings – Hollow Stem Augers

The borings are advanced by turning an auger with a center opening of 3-¼ inches. A plug device blocks off the center opening while augers are advanced. Cuttings are brought to the surface by the auger flights. Sampling is performed through the center opening in the hollow stem auger, by standard methods, after removal of the plug. Usually, no water is introduced into the boring using this procedure.

2. Standard Penetration Tests

Standard penetration tests are performed by driving a 2-inch O.D., 1-¾ inch I.D. sampling spoon with a 140-pound hammer falling 30 inches, according to ASTM D-1586. After an initial 6 inches penetration to assure the sampling spoon is in undisturbed material, the number of blows required to drive the sampler an additional 12 inches is generally taken as the N value. In the event 30 or more blows are required to drive the sampling spoon the initial 6 inch interval, the sampling spoon is driven to a total penetration resistance of 100 blows or 18 inches, whichever occurs first.

3. Undisturbed Tube Samples

Undisturbed tube sampling is accomplished by inserting 3-inch I.D. thin walled steel tubes into the soil through the hollow stem of the augers with hydraulically actuated rams.

4. Temporary Groundwater Observation Standpipes

A temporary groundwater observation standpipe was installed in test boring BH-01 to observe groundwater levels. The standpipe was installed by inserting a 1-¼ inch diameter plastic pipe through the 2-¼ inch center opening of the auger. Groundwater level observations were made as shown on the test boring log. The standpipe was removed from the test boring after completion of the final water level reading.

5. Test Boring Stakeout

The test boring stakeout was provided by GeoConcepts personnel using available site plans. Ground surface elevations were estimated from topographic information contained on the site plan provided to us and should be considered approximate. If the risk related to using approximate boring locations and elevations is unacceptable, we recommend an as-drilled survey of boring locations and elevations be completed by a licensed surveyor.

Identification of Soil

I. DEFINITION OF SOIL GROUP NAMES		ASTM D-2487	Symbol	Group Name
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines	<i>GW</i>	WELL GRADED GRAVEL
			<i>GP</i>	POORLY GRADED GRAVEL
		Gravels with Fines More than 12% fines	<i>GM</i>	silty GRAVEL
			<i>GC</i>	clayey GRAVEL
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines	<i>SW</i>	WELL GRADED SAND
			<i>SP</i>	POORLY GRADED SAND
		Sands with fines More than 12% fines	<i>SM</i>	silty SAND
			<i>SC</i>	clayey SAND
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	Inorganic	<i>CL</i>	LEAN CLAY
			<i>ML</i>	SILT
		Organic	<i>OL</i>	ORGANIC CLAY
				ORGANIC SILT
	Silts and Clays Liquid Limit 50 or more	Inorganic	<i>CH</i>	FAT CLAY
			<i>MH</i>	ELASTIC SILT
		Organic	<i>OH</i>	ORGANIC CLAY
				ORGANIC SILT
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor		<i>PT</i>	PEAT

II. DEFINITION OF MINOR COMPONENT PROPORTIONS

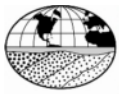
<u>Minor Component</u>	<u>Approximate Percentage of Fraction by Weight</u>
Gravelly, Sandy (adjective)	30% or more coarse grained
Sand, Gravel	15% to 29% coarse grained
Silt, Clay	5% to 12% fine grained

III. GLOSSARY OF MISCELLANEOUS TERMS

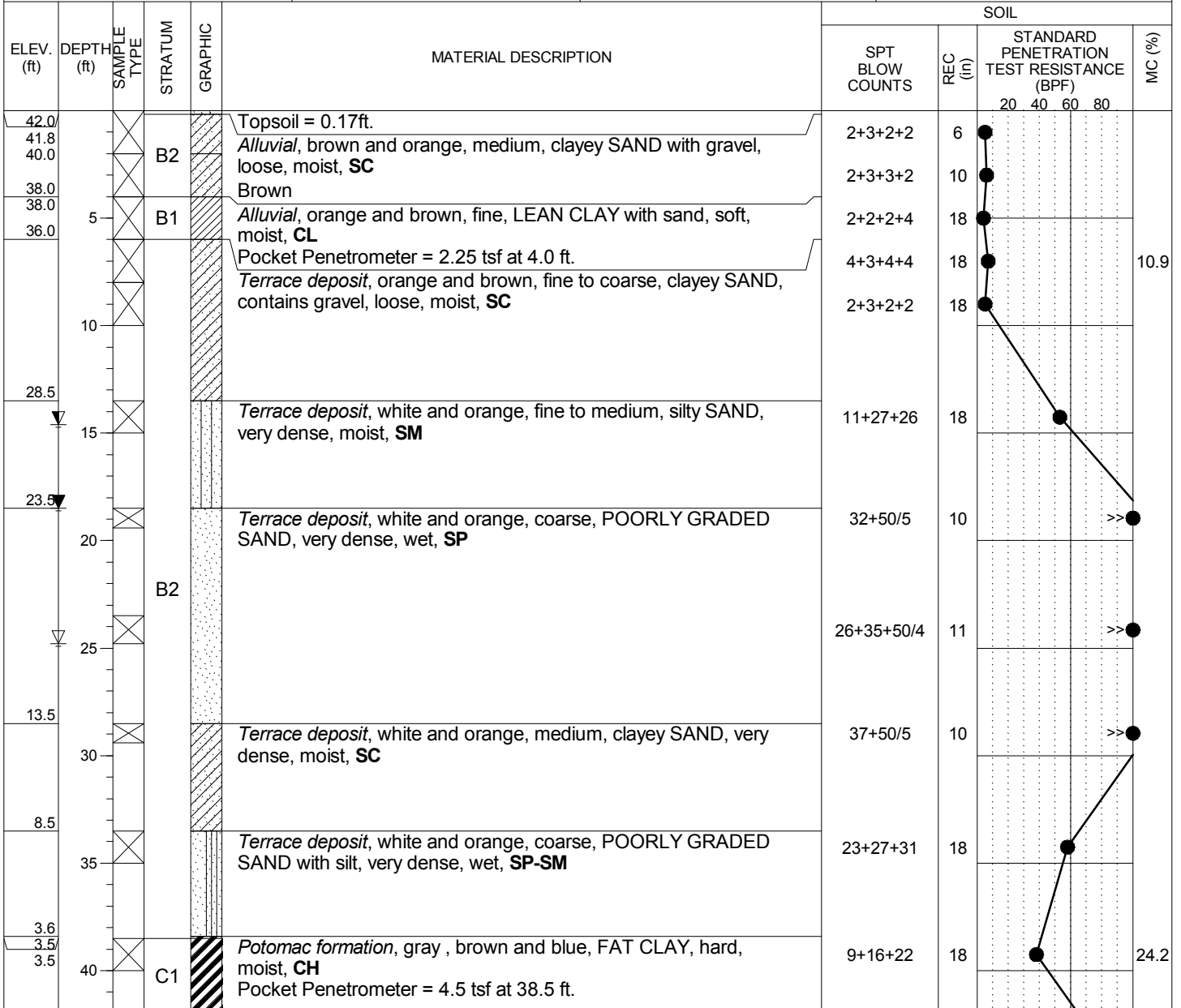
SYMBOLS	Unified Soil Classification Symbols are shown above as group symbols. Use "A" Line Chart for laboratory identification. Dual symbols are used for borderline classification.
BOULDERS & COBBLES	Boulders are considered pieces of rock larger than 12 inches, while cobbles range from 3 to 12 inches.
WEATHERED ROCK	Residual rock material with a standard penetration test (SPT) resistance of at least 60 blows per foot.
ROCK/SPOON REFUSAL	Rock material with a standard penetration test (SPT) resistance of 50 blows for 1 inch.
ROCK FRAGMENTS	Angular pieces of rock which have separated from original vein or strata and are present in a soil matrix. Only used in residual soils
QUARTZ	A hard silicate mineral often found in residual soils. Only used when describing residual soils.
CEMENTED SAND	Usually localized rock-like deposits within a soil stratum composed of sand grains cemented by calcium carbonate, iron oxide, or other minerals. Commonly encountered in Coastal Plain sediments, primarily in the Potomac Group sands (Kps).
MICACEOUS	A term used to describe soil that "glitters" or is shiny. Most commonly encountered in fine-grained soils.
ORGANIC MATERIALS (Excluding Peat)	Topsoil - Surface soils that support plant life and contain organic matter.
FILL	Lignite - Hard, brittle decomposed organic matter with low fixed carbon content (a low grade of coal).
CONTAINS	Man-made deposit containing soil, rock, and other foreign matter.
	This is used when a fill deposit contains a secondary component that does not apply to a USCS classification. Only used for fill deposits
WITH	This is used when a residual soil contains a secondary component that does not contribute to its USCS classification. Only used for natural soils.
PROBABLE FILL LAYERS	Soils which contain no visually detected foreign matter but which are suspect with regard to origin.
COLOR	1/2 to 12 inch seam of minor soil component.
MOISTURE CONDITIONS	Two most predominant colors present should be described.
f-m-c	Wet, moist, or dry to indicate visual appearance of specimen.
	Fine-medium-coarse

Test Boring Notes

1. Classification of soil is by visual inspection and is in accordance with ASTM D-2488.
2. Estimated groundwater levels are indicated on the logs. These are only estimates from available data and may vary with precipitation, porosity of soil, site topography, etc.
3. Sampling data presents standard penetrations for 6-inch intervals or as indicated with graphic representations adjacent to the sampling data. Where undisturbed tube samples are taken, they are designated "Shelby Tube" on the test boring log. The column with the header of the letters "PP" stands for pocket penetrometer, which is a measure of undrained shear strength (S_u).
4. The logs and related information depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at the test locations. Also, the passage of time may result in a change in the subsurface conditions at the test locations.
5. The stratification lines represent the approximate boundary between soil types as determined in the sampling operation. Some variation may be expected vertically between samples taken. The soil profile, groundwater level observations and penetration resistances presented on the logs have been made with reasonable care and accuracy and must be considered only an approximate representation of subsurface conditions to be encountered at the particular location.

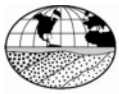


PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: BH-01
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 1/7/16 - 1/7/16
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 42.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:



GROUND WATER LEVELS:		SAMPLE TYPES: Split Spoon
ENCOUNTERED:	24.8 ft ELEV. 17.2	
UPON COMPLETION:	14.6 ft ELEV. 27.4	
1/10/2016	18.5 ft ELEV. 23.5	

REMARKS: Temporary standpipe installed to record long term groundwater level.



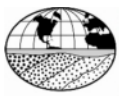
PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: BH-01
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
SHEET 2 OF 2			

ELEV. (ft)	DEPTH (ft)	SAMPLE TYPE	STRATUM	GRAPHIC	MATERIAL DESCRIPTION	SPT BLOW COUNTS	REC (in)	SOIL			
								STANDARD PENETRATION TEST RESISTANCE (BPF)			
								20	40	60	80
-1.5	45	X	C1		Potomac formation, gray , brown and blue, FAT CLAY, hard, moist, CH (continued) Very hard, Pocket Penetrometer = 4.5 tsf at 43.5 ft.	26+39+48	18				
-6.5	50	X			Pocket Penetrometer = 4.5 tsf at 48.5 ft.	27+30+35	18				
-11.5 -11.5	55	X			Hard, Pocket Penetrometer = 4.5 tsf at 53.5 ft.	14+24+24	18				
-16.5	60	X	C2		Potomac formation, gray , brown and blue, fine, clayey SAND, very dense, moist, SC	19+34+39	18				
-21.5 -21.5	65	X			Potomac formation, gray , brown and blue, fine, FAT CLAY with sand, very hard, moist, CH Pocket Penetrometer = 3.75 tsf at 63.5 ft.	19+34+39	18				
-26.5	70	X	C1		Pocket Penetrometer = 4.5 tsf at 68.5 ft.	37+37+45	18				
-31.5	75	X			Hard, Pocket Penetrometer = 4.5 tsf at 73.5 ft.	17+23+29	18				
-36.5 -36.5	80	X			Very hard, Pocket Penetrometer = 4.5 tsf at 78.5 ft.	27+36+40	18				
-38.0					Bottom of Boring at 80.0 ft						
	85										

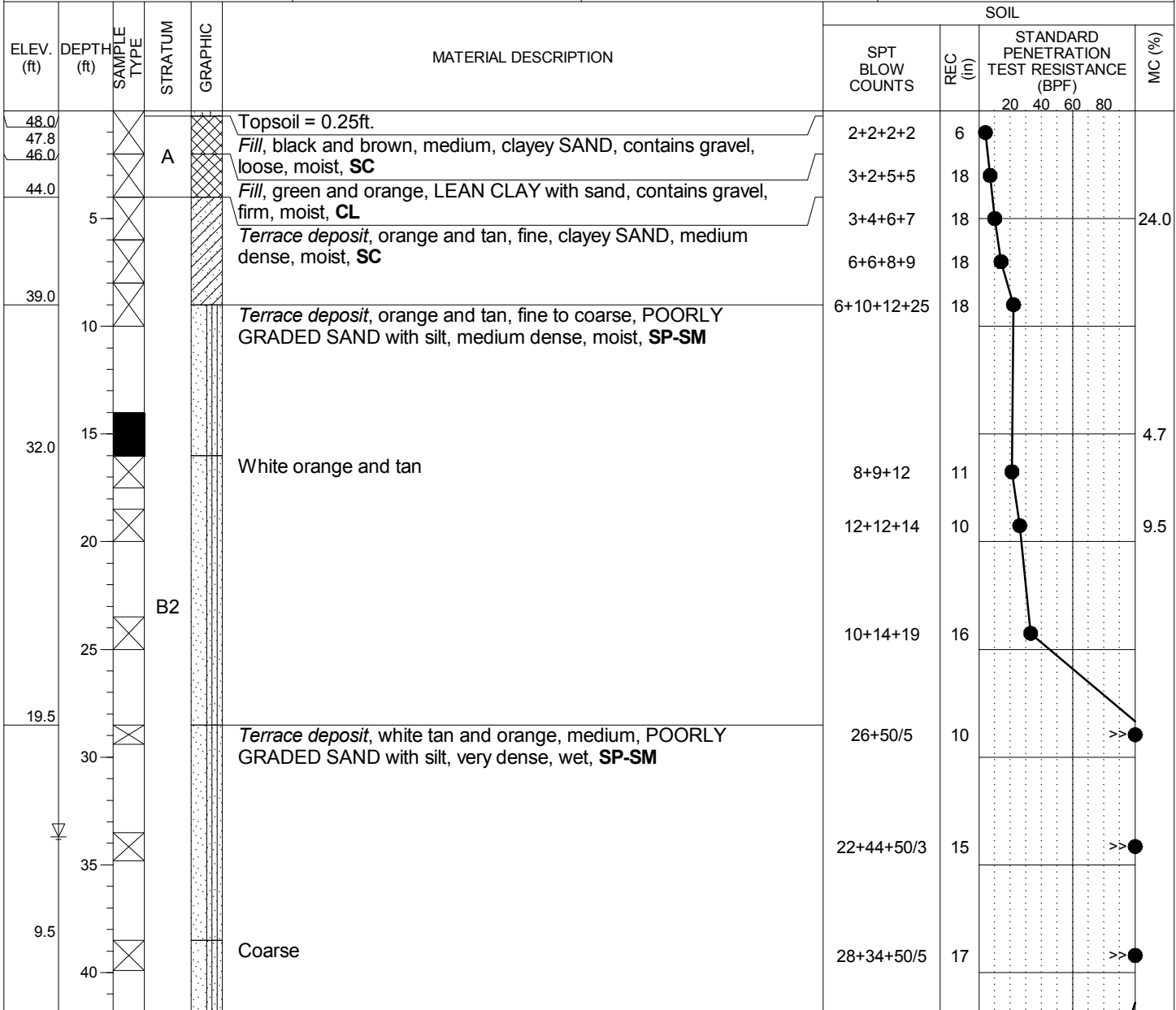
GROUND WATER LEVELS:		SAMPLE TYPES:
ENCOUNTERED:	24.8 ft ELEV. 17.2	Split Spoon
UPON COMPLETION:	14.6 ft ELEV. 27.4	
1/10/2016	18.5 ft ELEV. 23.5	
CAVED: 80.0 ft ELEV. -38.0		

REMARKS: Temporary standpipe installed to record long term groundwater level.

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: BH-02
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 1/7/16 - 1/7/16
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 48.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:



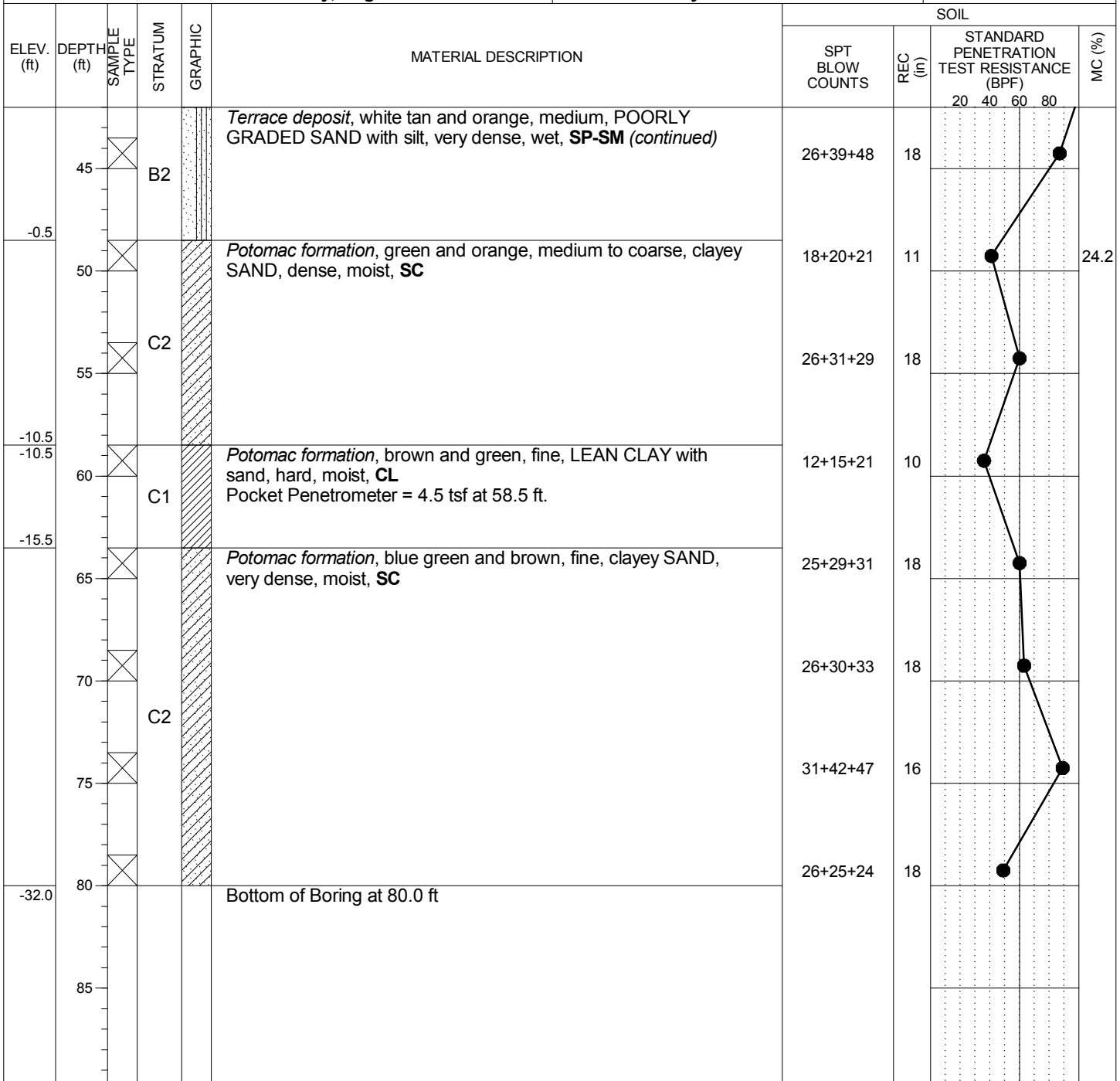
GROUND WATER LEVELS:		SAMPLE TYPES: Split Spoon Shelby Tube
ENCOUNTERED: <u>33.7</u> ft ELEV. <u>14.3</u>	CAVED: <u>15.3</u> ft ELEV. <u>32.7</u>	
NOT ENCOUNTERED UPON COMPLETION		

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: BH-02
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
SHEET 2 OF 2			



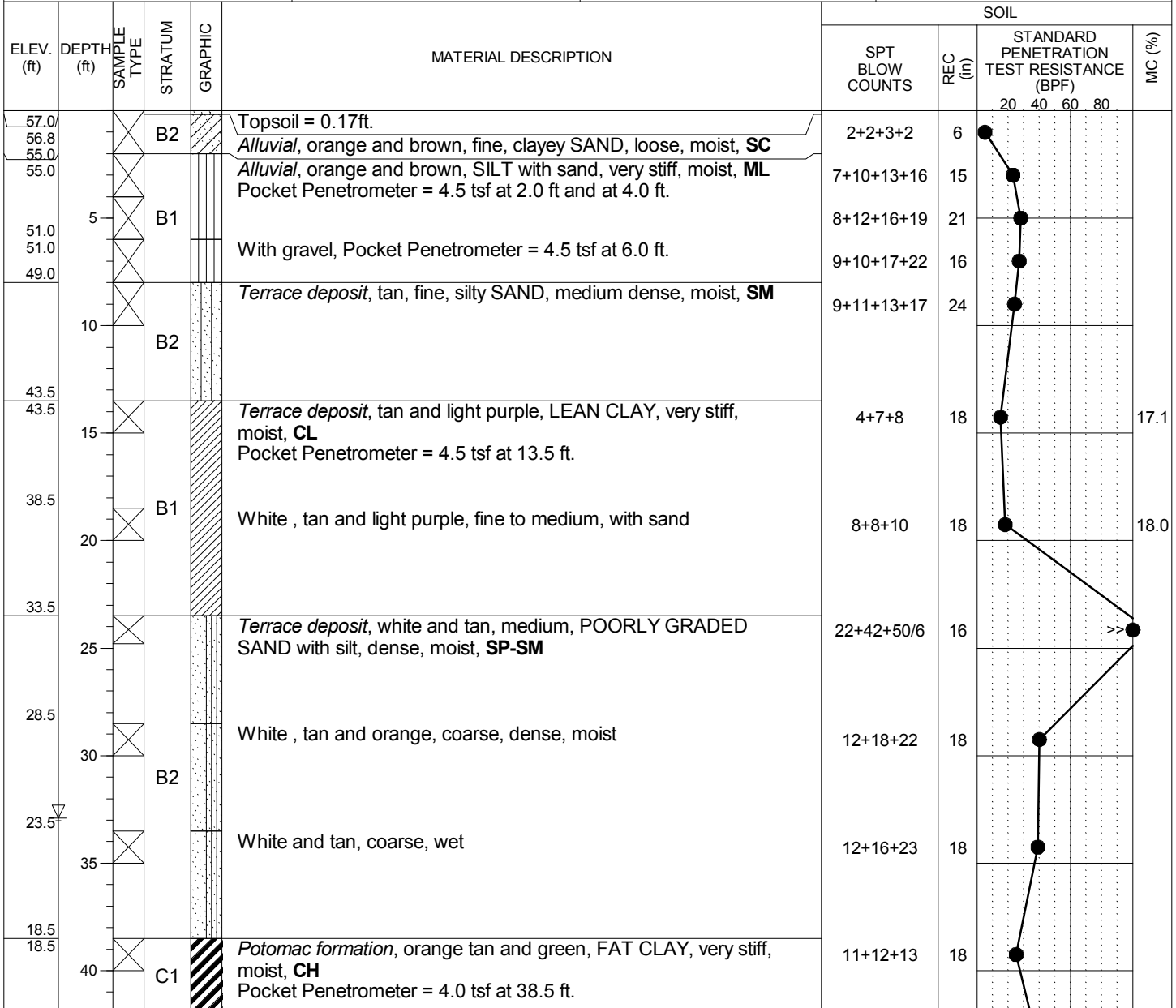
GROUND WATER LEVELS:		SAMPLE TYPES:	
ENCOUNTERED:	33.7 ft ELEV. 14.3		Split Spoon
NOT ENCOUNTERED UPON COMPLETION	CAVED: 15.3 ft ELEV. 32.7		Shelby Tube

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



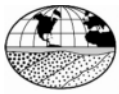
PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: BH-03
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 1/7/16 - 1/7/16
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 57.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:



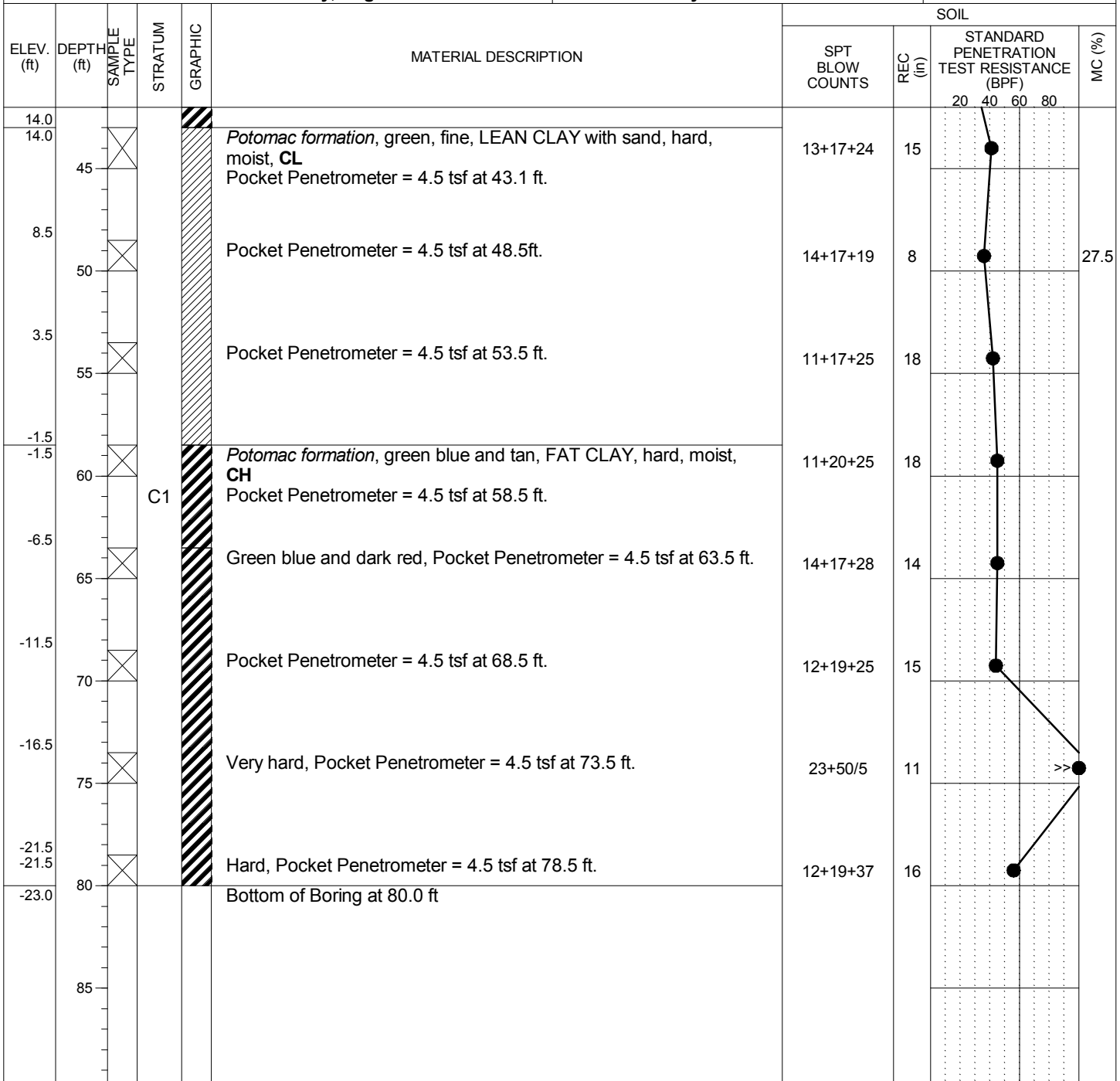
GROUND WATER LEVELS:		SAMPLE TYPES: Split Spoon
ENCOUNTERED: <u>32.9</u> ft ELEV. <u>24.1</u>	CAVED: <u>80.0</u> ft ELEV. <u>-23.0</u>	
NOT ENCOUNTERED UPON COMPLETION		

REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: BH-03
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
SHEET 2 OF 2			

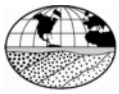


GROUND WATER LEVELS:		SAMPLE TYPES:
ENCOUNTERED: <u>32.9</u> ft ELEV. <u>24.1</u> NOT ENCOUNTERED UPON COMPLETION		<input checked="" type="checkbox"/> Split Spoon
CAVED: <u>80.0</u> ft ELEV. <u>-23.0</u>		

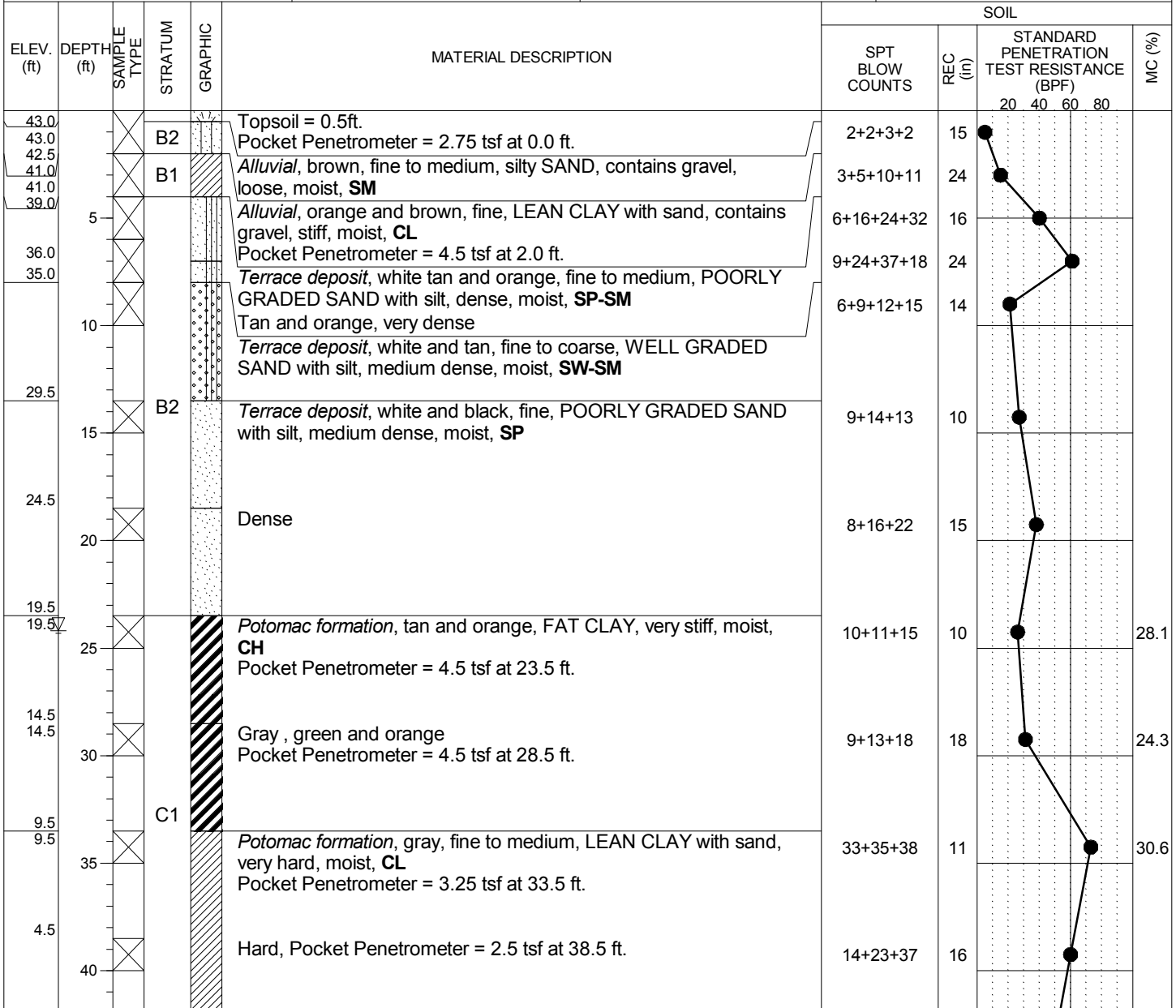
REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

BOREHOLE/TEST PIT ARKENDALE TO POWELLS LOGS.GPJ GEOCONCEPTS TEMPLATE 02-12-2015.GDT 3/9/16

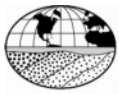


PROJECT: Arkendale-Powells Creek Third Track Project		LOGGED BY: M. Showalter	BORING NUMBER: BH-04
LOCATION: Prince William County, Virginia		DRILLING CONTRACTOR: Connelly & Associates Inc.	
OWNER/CLIENT: STV, Inc		DRILLER: J. Martinez	DATES DRILLED: 1/7/16 - 1/7/16
PROJECT NUMBER: 15184	GROUND SURFACE ELEVATION (ft): 43.0 ±	DRILLING METHOD: Automatic hammer 3.25"	OFFSET NOTES:

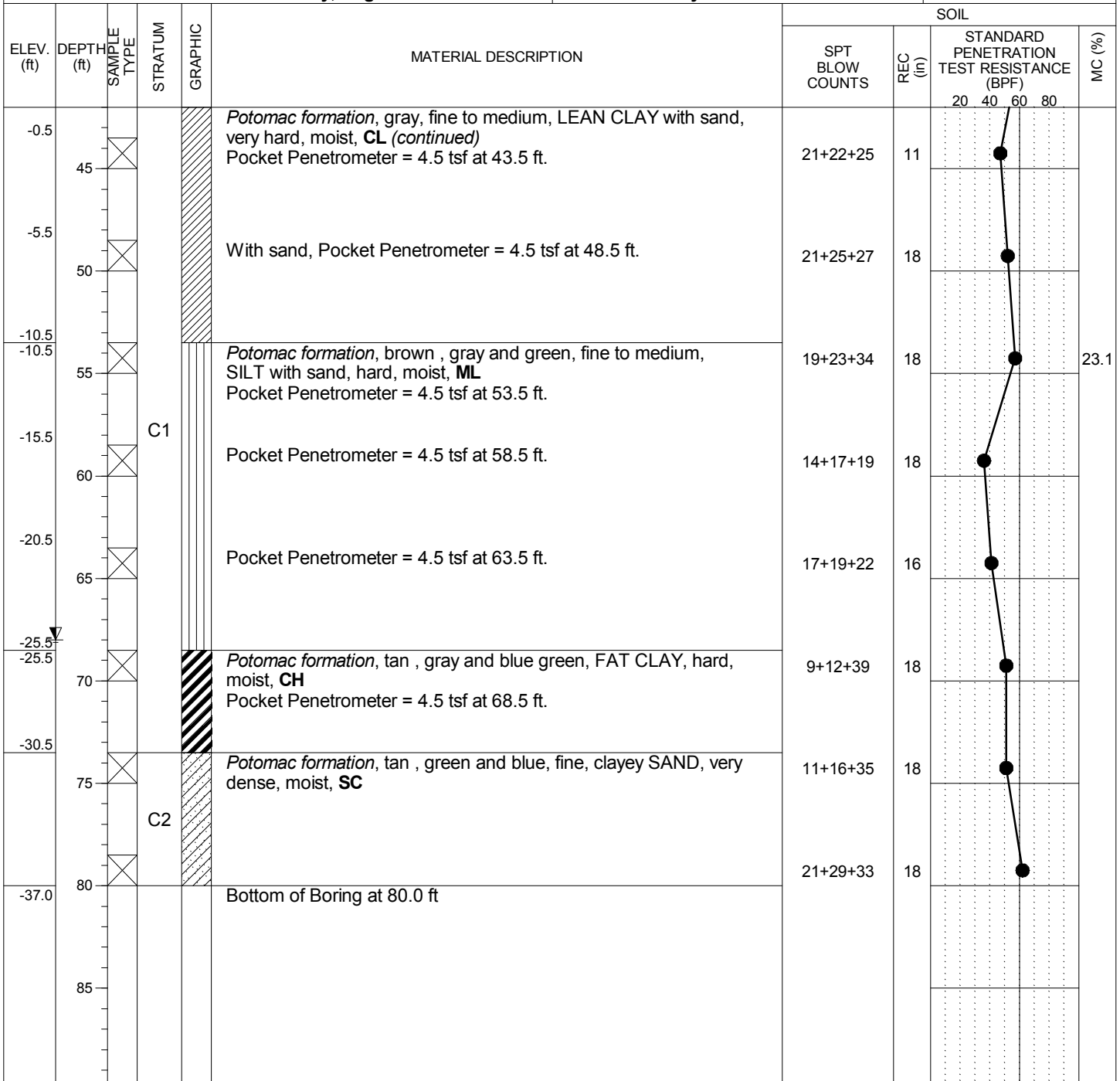


GROUND WATER LEVELS:		SAMPLE TYPES: Split Spoon
ENCOUNTERED:	24.2 ft ELEV. 18.8	
UPON COMPLETION:	68.0 ft ELEV. -25.0	
CAVED: 72.0 ft ELEV. -29.0		

REMARKS: Shelby tube collected at offset boring from 28.0 to 30.0 ft.



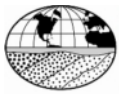
PROJECT: Arkendale-Powells Creek Third Track Project	LOGGED BY: M. Showalter	BORING NUMBER: BH-04
LOCATION: Prince William County, Virginia	DRILLING CONTRACTOR: Connelly & Associates Inc.	
		SHEET 2 OF 2



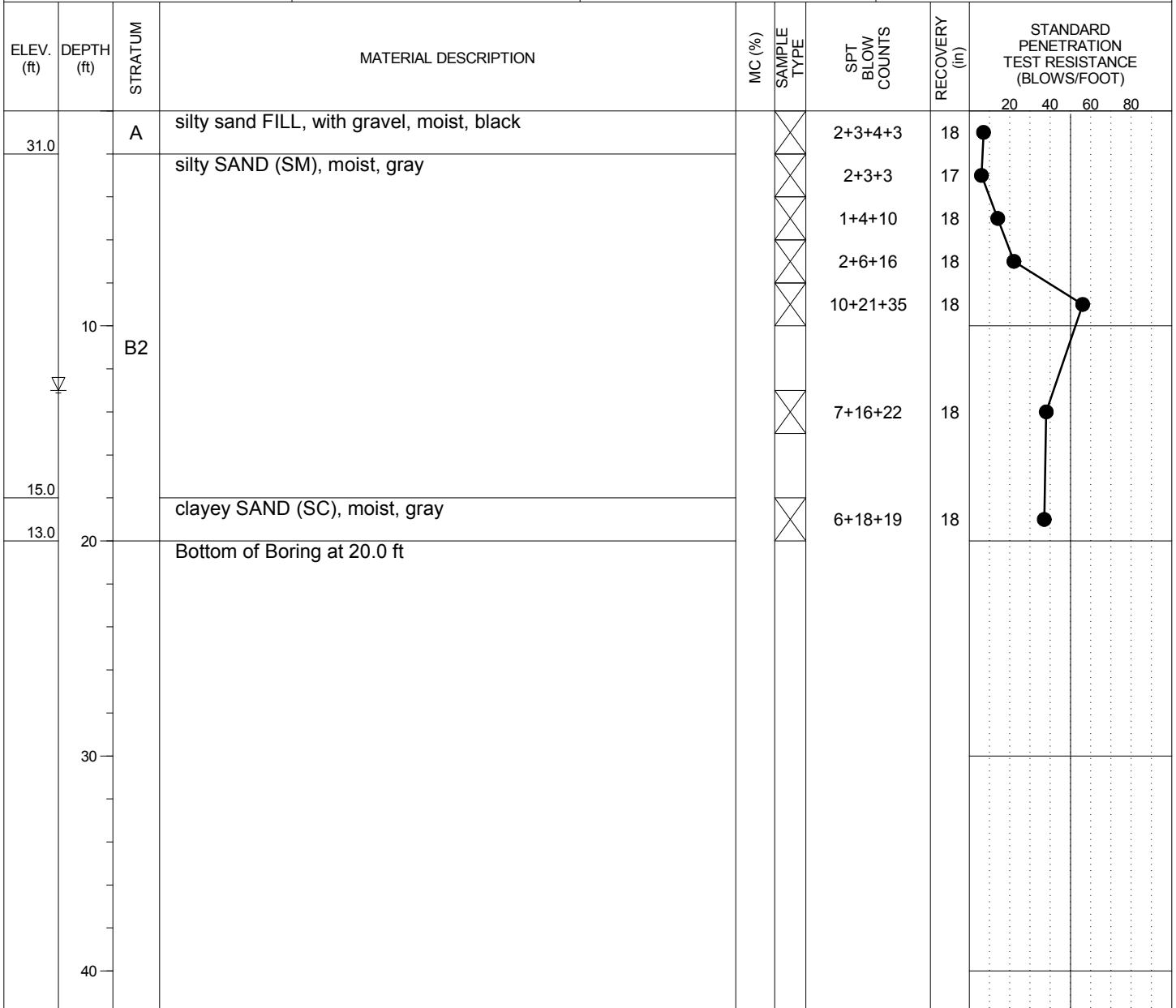
GROUND WATER LEVELS:	SAMPLE TYPES:
▽ ENCOUNTERED: <u>24.2</u> ft ELEV. <u>18.8</u> ▽ UPON COMPLETION: <u>68.0</u> ft ELEV. <u>-25.0</u> CAVED: <u>72.0</u> ft ELEV. <u>-29.0</u>	Split Spoon

REMARKS: Shelby tube collected at offset boring from 28.0 to 30.0 ft.

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.



PROJECT: VRE Cherry Hill Station/Third Track Project		LOGGED BY: S. Upadhyaya		BORING NUMBER: B-28
LOCATION: Prince William and Stafford Counties, Virginia		DRILLING CONTRACTOR: Fishburne Drilling Inc.		
OWNER/CLIENT: STV/Ralph Whitehead Associates		DRILLER: Sequist	DATE STARTED: 3/29/10	
PROJECT NUMBER: 28093	GROUND SURFACE ELEVATION (ft): 33.0	DRILLING METHOD: 3.75" HSA I.D.	DATE COMPLETED: 3/29/10	



GROUND WATER LEVELS: ENCOUNTERED: <u>13.0</u> ft ELEV. <u>20.0</u>	SAMPLE TYPES: Split Spoon
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





REMARKS:

THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES. THE TRANSITION MAY BE GRADUAL.

TEST BORING LOG

Boring No. RW-13-01
Page 1 of 1

	PROJECT: Arkendale-Powell's Creek (Cherry Hill) Third Track				COMMISSION NO.: 14-008-500			
	SITE: Stafford and Prince William Counties, Virginia				NORTH: 6875844			
	DRILLING CO.: F&R				EAST: 11828435			
RIG/HAMMER: CME55 Track / Auto				ELEVATION: 36.017 - ft				
START DATE: 9/2/2014				END DATE: 9/2/2014				
DRILLER: C. Sequist				LOGGED BY: MRS				

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in)	BLOWS/6" (% RQD)	LABORATORY TEST RESULTS			DEPTH	ELEV. DEPTH	GRAPHIC	DESCRIPTION AND CLASSIFICATION (moisture, density, color, proportions, etc.)	NOTES:	
				NMC/ Frac. Freq.	LIQUID LIMIT	PLASTICITY INDEX						
S-1	X	15	7 7 6	6.8%	19	6	5	EL 35.4 0.6		7-in Topsoil		
S-2	X	16	9 12 9					Moist, Medium Dense, Brown, Coarse to Fine SAND, Little Silt, Trace Clay (SC-SM) {A-2-4}				
S-3	X	10	11 8 5					Sample S-2: Gray to Orange-Brown				
S-4	X	18	3 4 11					Sample S-3: Gray-Brown				
S-5	X	15	13 16 22	20%			10	EL 25.5 10.5		Moist, Hard, Gray, SILT, Some Fine Sand, Little Clay (ml) {a-6}		
S-6	X	12	22 42 50/3"				15	EL 23.0 13.0		Moist, Very Dense, Gray to Orange-Brown, Coarse to Fine SAND, And Clay, Trace Silt (sc) {a-6}		
S-7	X	14	22 36 42	24.5%	66	46	20	Water On Rods At 18-ft		Moist, Very Dense, Gray to Orange-Brown, Coarse to Fine SAND, Some Clay, Trace Silt (sc) {a-2-6}		
S-8	X	18	7 15 14					25	EL 18.0 18.0			Moist, Very Stiff, Gray to Orange-Brown, High Plasticity CLAY, Some Coarse to Fine Sand, Little Silt (CH) {A-7-6}
S-9	X	13	24 28 31					Sample S-9: Hard				
S-10	X	10	32 50/4"				30	EL 9.0 27.0		Moist, Very Dense, Gray to Orange-Brown, Coarse to Fine SAND, Some Clay, Trace Silt (sc) {a-6}		
								EL 6.7 29.3		Bottom of Boring @ 29.3 ft	Boring Left Open For 24-hr Groundwater Reading, Then Backfilled	

SAMPLE IDENTIFICATION		DRILLING METHOD	BLOWS/FT	DENSITY	BLOWS/FT	CONSISTENCY	SAMPLE PROPORTIONS (PERCENT)	
	- S - SPLIT SPOON	HSA - HOLLOW STEM AUGERS	0-4	VERY LOOSE	0-2	VERY SOFT	TRACE	1 TO 10
	- T - THIN WALL TUBE	SSA - SOLID STEM AUGERS	5-10	LOOSE	3-4	SOFT	LITTLE	11 TO 20
	- SS - 3" SPLIT SPOON	DC - DRIVING CASING	11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	SOME	21 TO 35
	- D - DENISON	MD - MUD DRILLING	31-50	DENSE	9-15	STIFF	AND	36 TO 50
	- RC - ROCK CORE	HA - HAND AUGER	16-30	VERY DENSE	16-30	VERY STIFF		
			OVER 50		OVER 30	HARD		

Boring No. RW-13-01

RKK NORTH/EAST (DEFAULT) CSX ARKENDALE.GPJ RKK_CURRENT.GDT 11/24/14

TEST BORING LOG

Boring No. RW-13-02
Page 1 of 1

PROJECT: Arkendale-Powell's Creek (Cherry Hill) Third Track SITE: Stafford and Prince William Counties, Virginia DRILLING CO.: F&R RIG/HAMMER: CME55 Track / Auto										COMMISSION NO.: 14-008-500 NORTH: 6875969 EAST: 11828527 ELEVATION: 27.501 - ft START DATE: 8/28/2014 END DATE: 8/28/2014 DRILLER: C. Sequist LOGGED BY: MRS			
GROUNDWATER DATA (ft)						EQUIPMENT		CASING		SAMPLER		CORE	
Date		Time		Water		Casing		Cave-In		TYPE		HSA	
8/28/2014		1:00:00 PM		Dry				3.5		SIZE, ID (in)		3.25	
										HAMMER WT. (lb)		140	
										HAMMER FALL (in)		30	

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in)	BLOWS/6" (% RQD)	LABORATORY TEST RESULTS			DEPTH	ELEV. DEPTH	GRAPHIC	DESCRIPTION AND CLASSIFICATION (moisture, density, color, proportions, etc.)	NOTES:
				NMC/ Frac. Freq.	LIQUID LIMIT	PLASTICITY INDEX					
S-1	X	3	3 2 2	23.9%				EL 24.5 3.0	X	FILL, Sampled As: Moist, Very Loose, Brown, Coarse to Fine SAND, Some Silt, Trace Fine Gravel	
S-2	X	18	10 13 18				5	EL 22.5 5.0	X	Moist, Dense, Gray to Orange-Brown, Coarse to Fine SAND, Little Silt (sm) {a-2-4}	
										Bottom of Boring @ 5.0 ft	Difficulties Maintaining Position of Lead Auger, Concerns With Proximity to Qwest and MCI Fiber Lines. Boring Abandoned at 5-ft. Unable to Offset Due to Proximity to Tracks and Adjacent Slope. Boring Backfilled Upon Removal of Auger.

SAMPLE IDENTIFICATION		DRILLING METHOD		BLOWS/FT	DENSITY	BLOWS/FT	CONSISTENCY	SAMPLE PROPORTIONS (PERCENT)	
	- S - SPLIT SPOON	HSA - HOLLOW STEM AUGERS		0-4	VERY LOOSE	0-2	VERY SOFT	TRACE	1 TO 10
	- T - THIN WALL TUBE	SSA - SOLID STEM AUGERS		5-10	LOOSE	3-4	SOFT	LITTLE	11 TO 20
	- SS - 3" SPLIT SPOON	DC - DRIVING CASING		11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	SOME	21 TO 35
	- D - DENISON	MD - MUD DRILLING		31-50	DENSE	9-15	STIFF	AND	36 TO 50
	- RC - ROCK CORE	HA - HAND AUGER		OVER 50	VERY DENSE	16-30	VERY STIFF		
						OVER 30	HARD		

Boring No. RW-13-02

RKK NORTH/EAST (DEFAULT) CSX ARKENDALE.GPJ RKK_CURRENT.GDT 11/24/14

TEST BORING LOG

Boring No. RW-13-05
Page 1 of 1

	PROJECT: Arkendale-Powell's Creek (Cherry Hill) Third Track				COMMISSION NO.: 14-008-500			
	SITE: Stafford and Prince William Counties, Virginia				NORTH: 6876104			
	DRILLING CO.: F&R				EAST: 11828609			
RIG/HAMMER: CME55 Track / Auto				ELEVATION: 25.479 - ft				
START DATE: 8/28/2014				END DATE: 8/28/2014				
DRILLER: C. Sequist				LOGGED BY: MRS				

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in)	BLOWS/6" (% RQD)	LABORATORY TEST RESULTS			DEPTH	ELEV. DEPTH	GRAPHIC	DESCRIPTION AND CLASSIFICATION (moisture, density, color, proportions, etc.)	NOTES:
				NMC/ Frac. Freq.	LIQUID LIMIT	PLASTICITY INDEX					
S-1	X	5	WOH 1 3	27.9%	27	10		EL 22.5 3.0	X	FILL, Sampled As: Moist, Very Loose, Dark Brown, Coarse to Fine SAND, And Clay, Trace Fine Gravel, Trace Organics	
S-2	X	15	2 3 3				▽	EL 20.0 5.5		Wet, Loose, Tan, Coarse to Fine SAND, Little Silt (sm) {a-2-4}	Water Measured At 4.5-ft After Augers Removed
S-3	X	14	6 13 16							Moist, Medium Dense, Tan to Orange-Brown, Medium to Fine SAND, Some Medium Plasticity Clay (SC) {A-2-6}	Water On Spoon At 7-ft
S-4	X	18	5 6 5	27.6%	33	15				Sample S-4: Gray to White, Little Clay, Trace Silt	
S-5	X	18	4 5 8							Sample S-5: Wet, Trace Silt	
S-6	X	16	9 13 16							Sample S-6: Orange-Brown, And Clay, Little Silt {a-6}	
S-7	X	14	10 13 16	27%				EL 10.0 15.5		Moist, Very Stiff, Green-Gray to Brown, CLAY, And Medium to Fine Sand, Little Silt (cl) {a-6}	
S-8	X	18	6 10 16					EL 5.5 20.0		Sample S-8: Green-Gray, Little Fine Sand	
										Bottom of Boring @ 20.0 ft	Boring Left Open For 24-hr Groundwater Reading, Then Backfilled

SAMPLE IDENTIFICATION		DRILLING METHOD	BLOWS/FT	DENSITY	BLOWS/FT	CONSISTENCY	SAMPLE PROPORTIONS (PERCENT)	
X	- S - SPLIT SPOON	HSA - HOLLOW STEM AUGERS	0-4	VERY LOOSE	0-2	VERY SOFT	TRACE	1 TO 10
	- T - THIN WALL TUBE	SSA - SOLID STEM AUGERS	5-10	LOOSE	3-4	SOFT	LITTLE	11 TO 20
	- SS - 3" SPLIT SPOON	DC - DRIVING CASING	11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	SOME	21 TO 35
X	- D - DENISON	MD - MUD DRILLING	31-50	DENSE	9-15	STIFF	AND	36 TO 50
■	- RC - ROCK CORE	HA - HAND AUGER	OVER 50	VERY DENSE	16-30	VERY STIFF		
					OVER 30	HARD		

RKK NORTH/EAST (DEFAULT) CSX ARKENDALE.GPJ RKK_CURRENT.GDT 11/24/14

Boring No. RW-13-05

TEST BORING LOG

Boring No. RW-13-06
Page 1 of 1

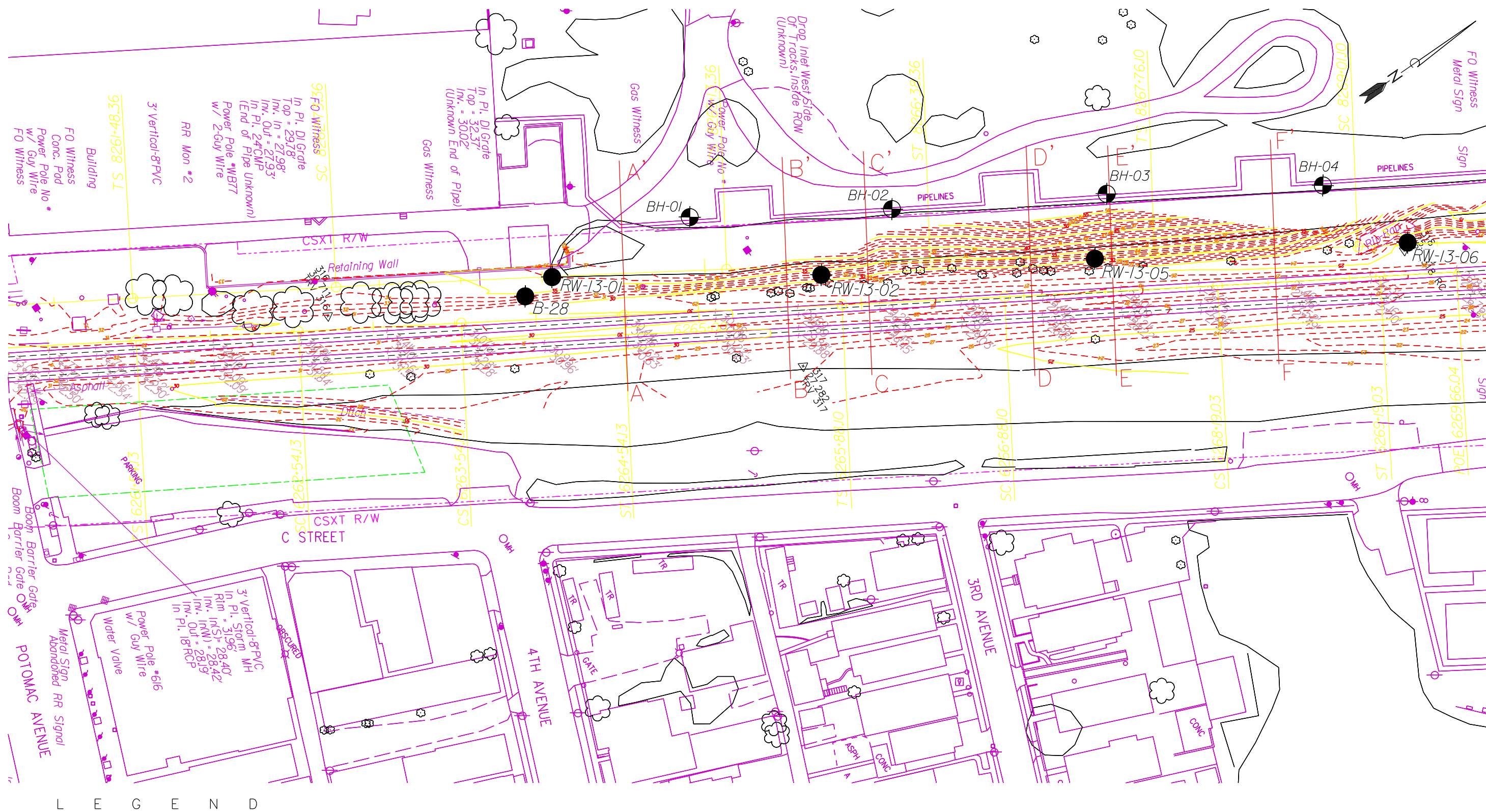
PROJECT: Arkendale-Powell's Creek (Cherry Hill) Third Track SITE: Stafford and Prince William Counties, Virginia DRILLING CO.: F&R RIG/HAMMER: CME55 Track / Auto										COMMISSION NO.: 14-008-500 NORTH: 6876247 EAST: 11828689 ELEVATION: 22.337 - ft START DATE: 8/27/2014 END DATE: 8/27/2014 DRILLER: C. Sequist LOGGED BY: MRS							
GROUNDWATER DATA (ft)										EQUIPMENT		CASING		SAMPLER		CORE	
Date		Time		Water		Casing		Cave-In		TYPE		HSA		S			
8/27/2014		5:00:00 PM		Dry				10.6		SIZE, ID (in)		3.25		1.375			
8/28/2014		9:00:00 AM		Dry				8.5		HAMMER WT. (lb)		140		-			
										HAMMER FALL (in)		30		-			

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in)	BLOWS/6" (% RQD)	LABORATORY TEST RESULTS			DEPTH	ELEV. DEPTH	GRAPHIC	DESCRIPTION AND CLASSIFICATION (moisture, density, color, proportions, etc.)	NOTES:
				NMC/ Frac. Freq.	LIQUID LIMIT	PLASTICITY INDEX					
S-1	X	12	WOH 1 1	23.6%						FILL, Sampled As: Moist, Very Soft, Dark Gray to Brown, CLAY, Some Medium to Fine Sand, Little Silt	Boring Completed In Existing Drainage Ditch
S-2	X	0	50/3"				5	EL 16.8 5.5		Sample S-2: Very Dense, No Recovery	Unable To Conventionally Extract Spoon After Taking Sample S-2, Rig Settling When Applying Additional Down Pressure. Attach Rods To Drive And Rotate Spoon To Remove.
S-3	X	12	16 20 23				10	EL 11.8 10.5		Moist, Dense, White to Brown, Medium to Fine SAND, Little Silt, Trace Coarse Subangular Gravel (sm) {a-2-4}	
S-4	X	5	24 27 18							Sample S-4: Trace Clay	
S-5	X	16	15 20 18	19%						Moist, Dense, White to Gray to Brown, Coarse to Fine SAND, Some Clay, Trace Silt (sc) {a-2-6}	
S-6	X	16	11 13 10				15	EL 7.3 15.0		Sample S-6: Medium Dense, Orange-Brown	
										Bottom of Boring @ 15.0 ft	
							20				Boring Left Open For 24-hr Groundwater Reading, Then Backfilled
							25				

SAMPLE IDENTIFICATION		DRILLING METHOD		BLOWS/FT	DENSITY	BLOWS/FT	CONSISTENCY	SAMPLE PROPORTIONS (PERCENT)	
	- S - SPLIT SPOON	HSA - HOLLOW STEM AUGERS		0-4	VERY LOOSE	0-2	VERY SOFT	TRACE	1 TO 10
	- T - THIN WALL TUBE	SSA - SOLID STEM AUGERS		5-10	LOOSE	3-4	SOFT	LITTLE	11 TO 20
	- SS - 3" SPLIT SPOON	DC - DRIVING CASING		11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	SOME	21 TO 35
	- D - DENISON	MD - MUD DRILLING		31-50	DENSE	9-15	STIFF	AND	36 TO 50
	- RC - ROCK CORE	HA - HAND AUGER		OVER 50	VERY DENSE	16-30	VERY STIFF		
						OVER 30	HARD		

Boring No. RW-13-06

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L E G E N D



TEST BORING LOCATION

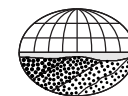
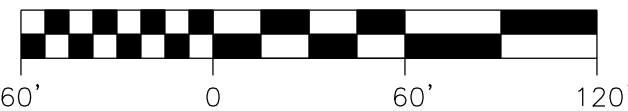


PREVIOUS TEST BORING LOCATION



GLOBAL STABILITY SECTION

GRAPHICAL SCALE



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ARKENDALE-POWELLS CREEK THIRD TRACK PROJECT
PRINCE WILLIAM COUNTY, VIRGINIA

BORING LOCATION PLAN

Scale:
AS SHOWN

Fig.

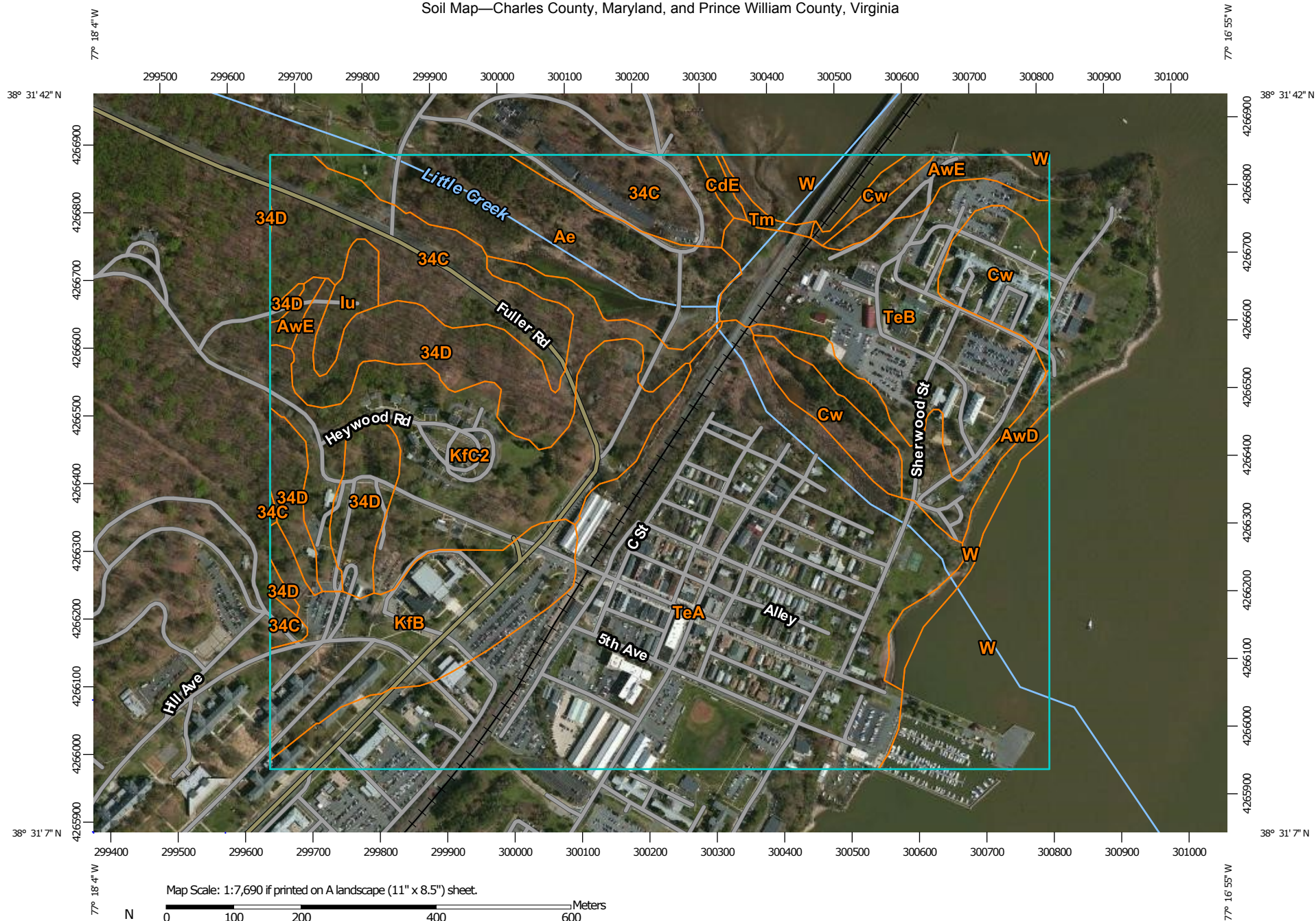
Date:
MAR. 2016

Checked By:
P.E.B.

Project No.:
15184

A-1

Soil Map—Charles County, Maryland, and Prince William County, Virginia



Map Scale: 1:7,690 if printed on A landscape (11" x 8.5") sheet.

0 100 200 400 600 Meters

0 350 700 1400 2100 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84



**Natural Resources
Conservation Service**

Web Soil Survey
National Cooperative Soil Survey

2/18/2016
Page 1 of 3

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

Special Point Features



Blowout



Borrow Pit



Clay Spot



Closed Depression



Gravel Pit



Gravelly Spot



Landfill



Lava Flow



Marsh or swamp



Mine or Quarry



Miscellaneous Water



Perennial Water



Rock Outcrop



Saline Spot



Sandy Spot



Severely Eroded Spot



Sinkhole



Slide or Slip



Sodic Spot



Spoil Area



Stony Spot



Very Stony Spot



Wet Spot



Other



Special Line Features

Water Features



Streams and Canals

Transportation



Rails



Interstate Highways



US Routes



Major Roads



Local Roads

Background



Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:15,800.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Charles County, Maryland
Survey Area Data: Version 9, Sep 18, 2015

Soil Survey Area: Prince William County, Virginia
Survey Area Data: Version 12, Dec 13, 2013

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Charles County, Maryland (MD017)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
W	Water	18.0	6.9%
Subtotals for Soil Survey Area		18.0	6.9%
Totals for Area of Interest		260.3	100.0%

Prince William County, Virginia (VA153)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
34C	Lunt loam, 7 to 15 percent slopes	21.7	8.3%
34D	Lunt loam, 15 to 25 percent slopes	21.8	8.4%
Ae	Alluvial land, wet	17.3	6.7%
AwD	Aura-Galestown-Sassafras complex, 6 to 15 percent slopes	6.2	2.4%
AwE	Aura-Galestown-Sassafras complex, 15 to 30 percent slopes	4.4	1.7%
CdE	Caroline-Sassafras complex, 15 to 30 percent slopes	0.6	0.2%
Cw	Cut and fill land	11.1	4.3%
Iu	Iuka fine sandy loam, local alluvium, 0 to 4 percent slopes	2.3	0.9%
KfB	Kempsville fine sandy loam, gravelly substratum, 2 to 6 percent slopes	18.4	7.1%
KfC2	Kempsville fine sandy loam, gravelly substratum, 6 to 10 percent slopes, eroded	26.1	10.0%
TeA	Tetotum fine sandy loam, 0 to 2 percent slopes	78.9	30.3%
TeB	Tetotum fine sandy loam, 2 to 6 percent slopes	24.7	9.5%
Tm	Tidal marsh	0.7	0.3%
W	Water	7.9	3.0%
Subtotals for Soil Survey Area		242.2	93.1%
Totals for Area of Interest		260.3	100.0%

Appendix B

Soil Laboratory Test Results

Liquid and Plastic Limit, and Grain Size Analysis Test Data (18 pages)

Direct Shear Test Data (2 pages)

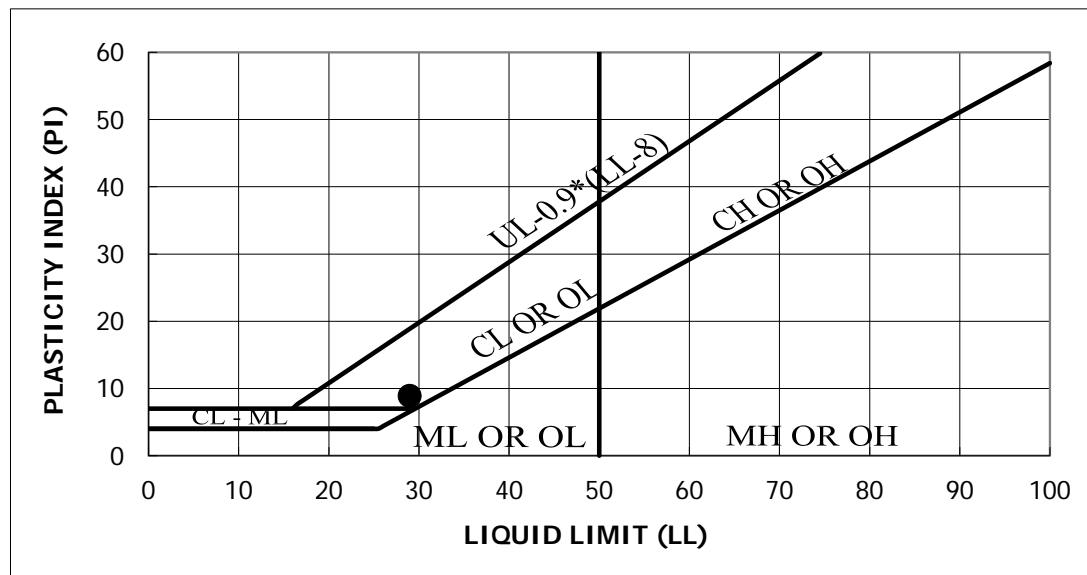
Consolidated Undrained (CU) Triaxial Test Data (5 pages)

Corrosion Series Test Data (1 page)



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-01	Depth (Feet)	6.0'-8.0'
Lab Order No.	3725-1	Date	2/5/2016



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
CLAYEY SAND	29	20	9	89.8	18.7	SC	10.9
Color	Brown		AASHTO Classification			A-2-4	

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Bantz

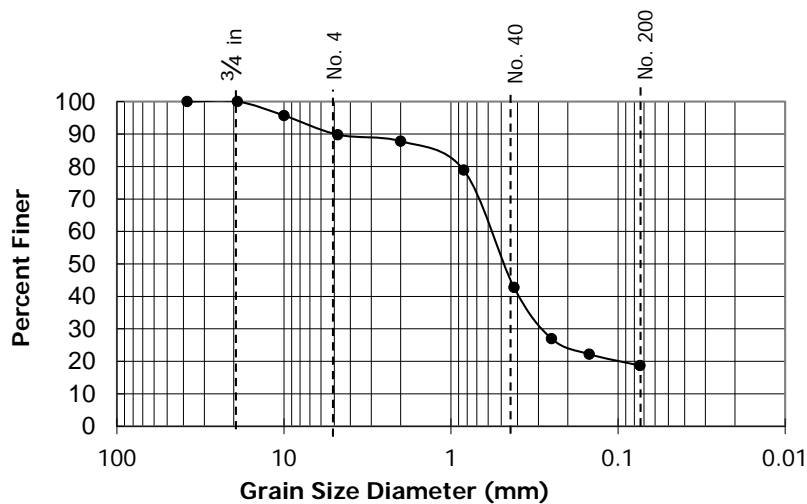


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-01	Depth (Feet)	6.0'-8.0'
Lab Order No.	3725-1	Date	2/5/2016



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	96
#4	90
#10	88
#20	79
#40	43
#60	27
#100	22
#200	19
Pan	--

USCS Group Symbol	SC
USCS Group Name	CLAYEY SAND
Cu	---
Cc	---
LL	29
PI	9
Gravel	10.2
Sand	71.1
Fines	18.7
AASHTO Classification	A-2-4
Color	Brown

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

Reviewed by: _____

Lindsay Bantz

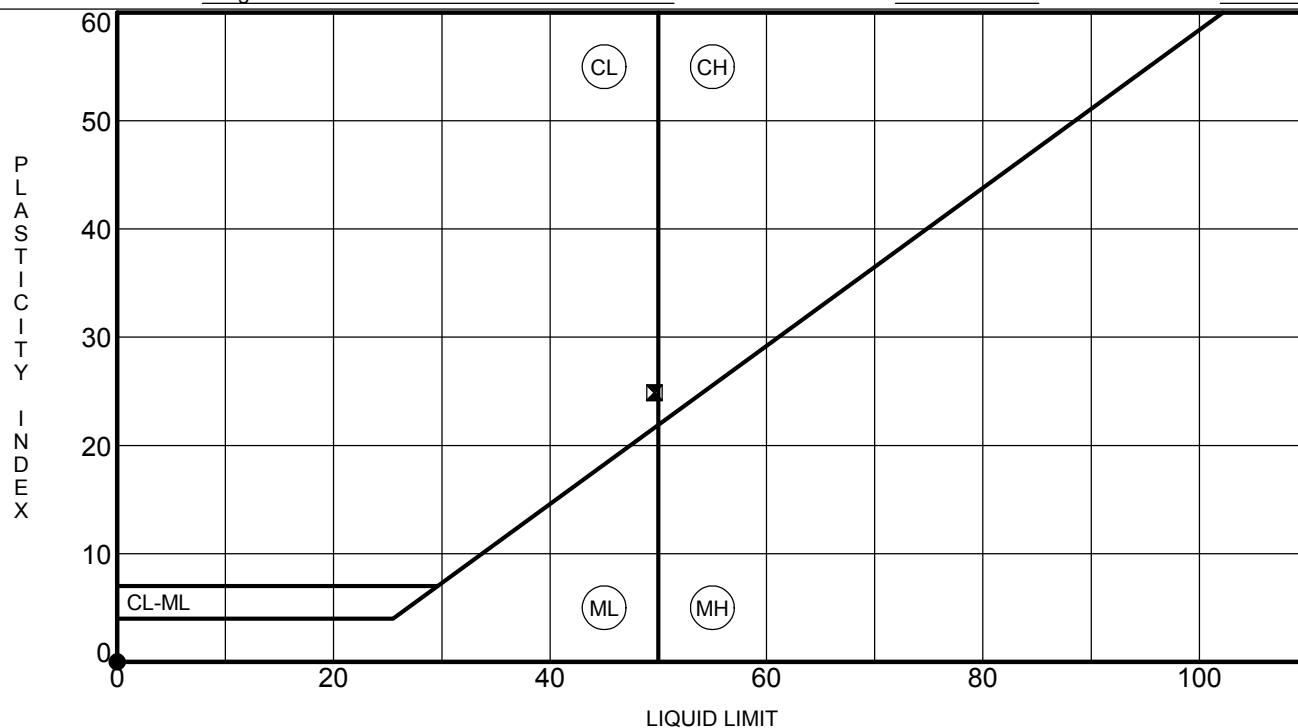
CLIENT Geoconcepts Engineering, Inc.

PROJECT NAME Arkendale-Powell's Creek Third Track

PROJECT LOCATION Virginia

PROJECT NUMBER 16752-0 VA

DATE TESTED 2/10/2016

[illegible]



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GRAIN SIZE DISTRIBUTION

TEST METHOD ASTM D422

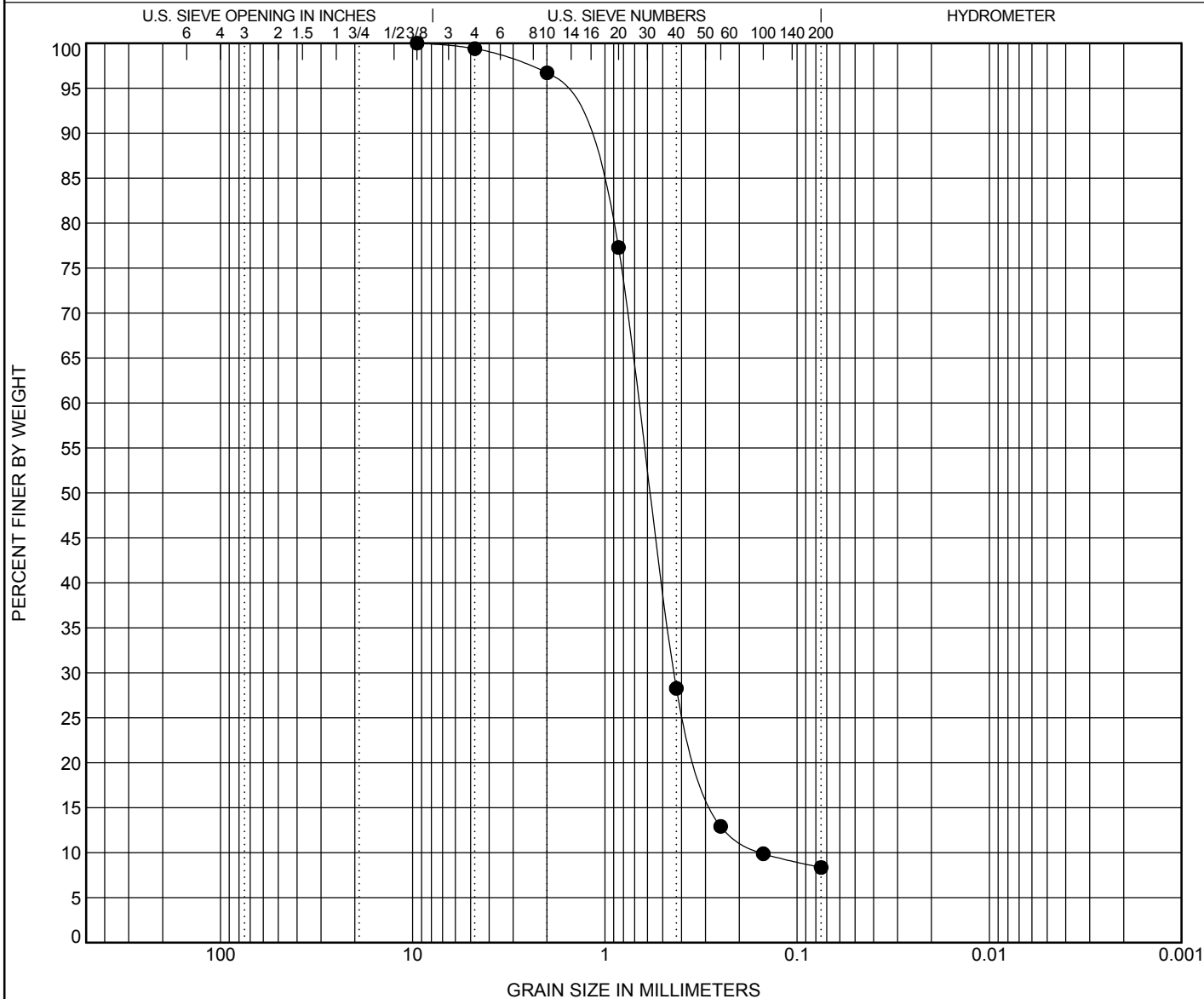
CLIENT Geoconcepts Engineering, Inc.

PROJECT NAME Arkendale-Powell's Creek Third Track

PROJECT LOCATION Virginia

PROJECT NUMBER 16752-0 VA

DATE TESTED 2/10/2016



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

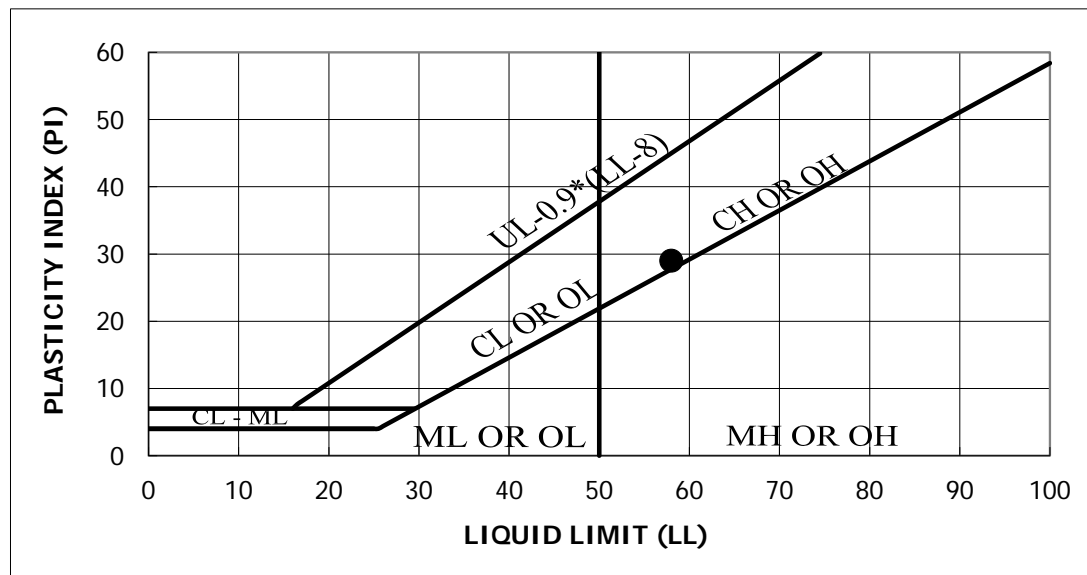
Specimen Identification		Classification					LL	PL	PI	Cc	Cu
● BH-02, Tube @ 14.0' - 16.0',		Brownish Yellow POORLY GRADED SAND with SILT(SP-SM)					NP	NP	NP	1.86	4.34
Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BH-02, Tube @ 14.0' - 16.0',		9.5	0.666	0.436	0.153	0.6	91.0	8.3			

GRAIN SIZE 16752-0 ARKENDALE-POWELL CREEK THIRD TRACK.GPJ MTA REDLINE.GDT 2/11/16



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-02	Depth (Feet)	48.5'-50.0'
Lab Order No.	3725-5	Date	2/5/2016



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
CLAYEY SAND	58	29	29	88.6	26.9	SC	24.2
Color	Gray		AASHTO Classification			A-2-7	

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Barty

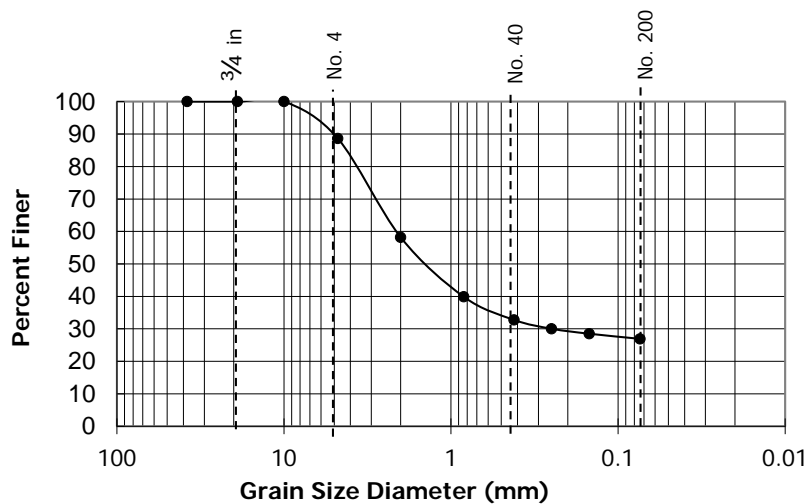


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-02	Depth (Feet)	48.5'-50.0'
Lab Order No.	3725-5	Date	2/5/2016



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	89
#10	58
#20	40
#40	33
#60	30
#100	29
#200	27
Pan	--

USCS Group Symbol	SC
USCS Group Name	CLAYEY SAND
Cu	---
Cc	---
LL	58
PI	29
Gravel	11.4
Sand	61.7
Fines	26.9
AASHTO Classification	A-2-7
Color	Gray

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

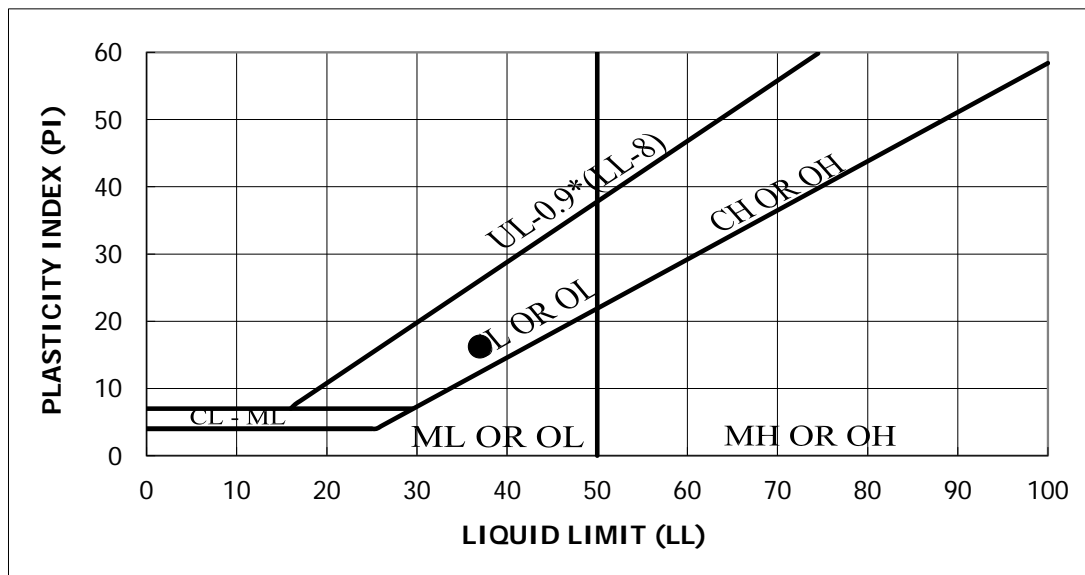
Reviewed by: _____

Lindsay Bantz



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-03	Depth (Feet)	13.5'-15.0'
Lab Order No.	3725-6	Date	2/5/2016



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
Lean Clay	37	21	16	100.0	86.8	CL	17.1
Color	Brown		AASHTO Classification			A-6	

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Bantz

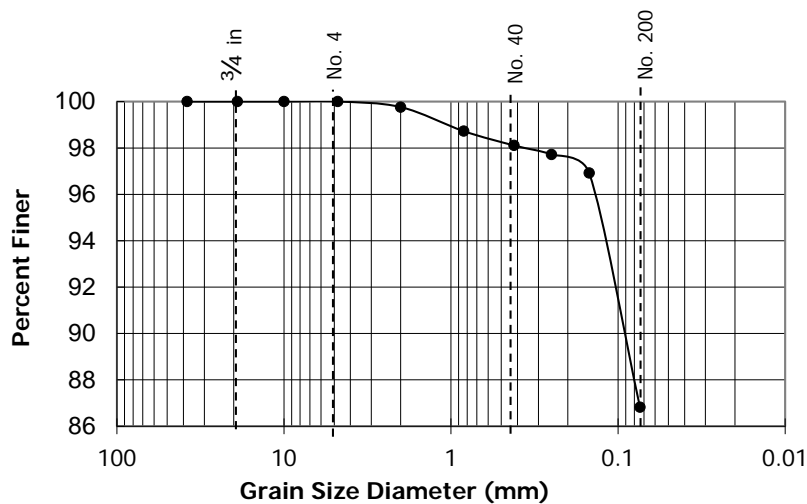


GeoConcepts Engineering, Inc.

19955 Highland Vista Dr., Suite 170
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(703) 726-8030
www.geoconcepts-eng.com

GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-03	Depth (Feet)	13.5'-15.0'
Lab Order No.	3725-6	Date	2/5/2016



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	100
#20	99
#40	98
#60	98
#100	97
#200	87
Pan	--

USCS Group Symbol	CL
USCS Group Name	Lean Clay
Cu	---
Cc	---
LL	37
PI	16
Gravel	0.0
Sand	13.2
Fines	86.8
AASHTO Classification	A-6
Color	Brown

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

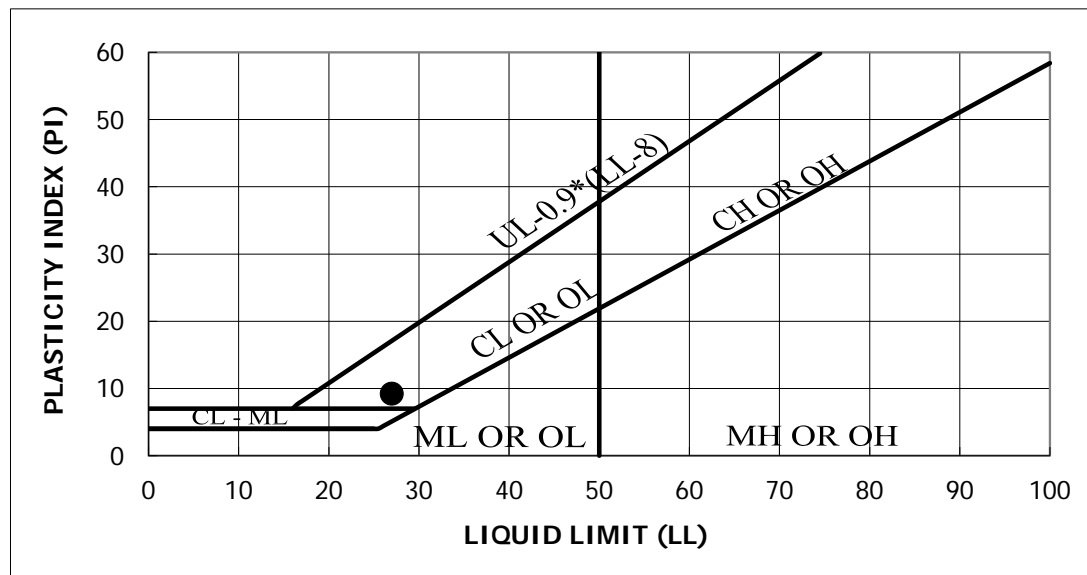
Reviewed by: _____

Lindsay Barty



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-03	Depth (Feet)	18.5'-20.0'
Lab Order No.	3725-7	Date	2/5/2016



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
Lean Clay with sand	27	18	9	99.6	80.7	CL	18.0
Color	Brownish Gray		AASHTO Classification			A-4	

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Bantz

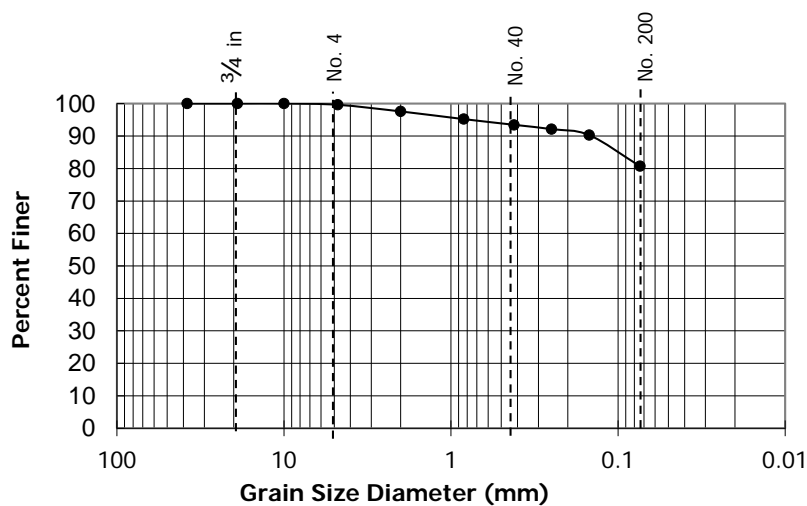


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-03	Depth (Feet)	18.5'-20.0'
Lab Order No.	3725-7	Date	2/5/2016



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	98
#20	95
#40	93
#60	92
#100	90
#200	81
Pan	--

USCS Group Symbol	CL
USCS Group Name	Lean Clay with sand
Cu	---
Cc	---
LL	27
PI	9
Gravel	0.4
Sand	18.9
Fines	80.7
AASHTO Classification	A-4
Color	Brownish Gray

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

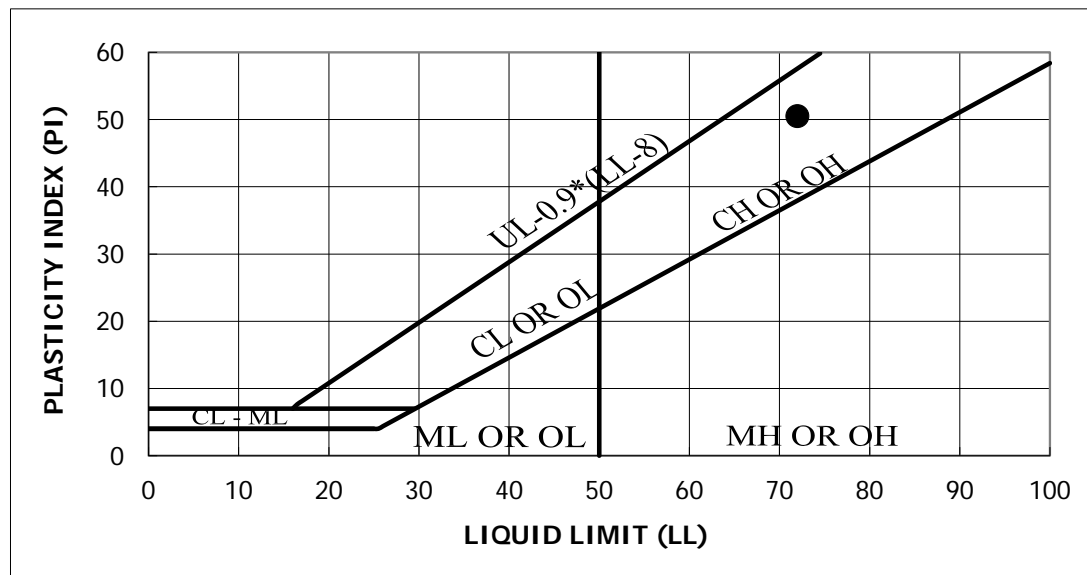
Reviewed by: _____

Lindsay Bantz



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-04	Depth (Feet)	23.5'-25.0'
Lab Order No.	3725-9	Date	2/5/2016



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
Fat Clay	72	21	51	100.0	91.5	CH	28.1
Color	Brown		AASHTO Classification			A-7-6	

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Bantz

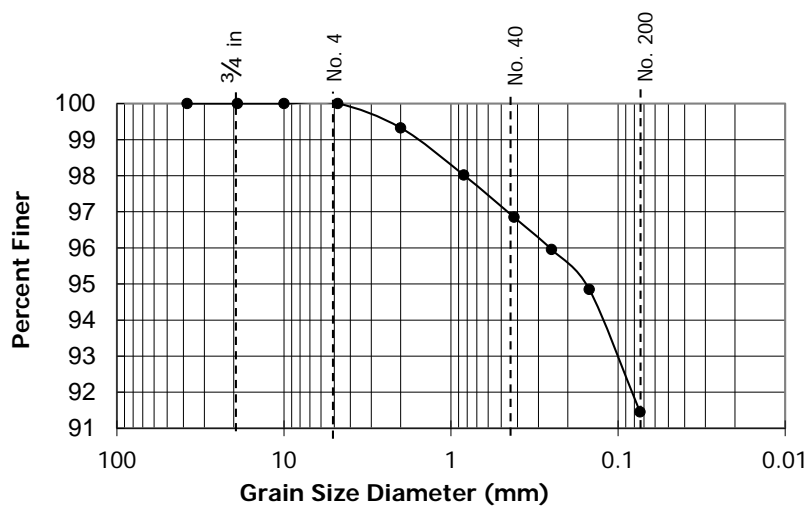


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-04	Depth (Feet)	23.5'-25.0'
Lab Order No.	3725-9	Date	2/5/2016



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	99
#20	98
#40	97
#60	96
#100	95
#200	91
Pan	--

USCS Group Symbol	CH
USCS Group Name	Fat Clay
Cu	---
Cc	---
LL	72
PI	51
Gravel	0.0
Sand	8.5
Fines	91.5
AASHTO Classification	A-7-6
Color	Brown

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

Reviewed by: _____

Lindsay Bantz

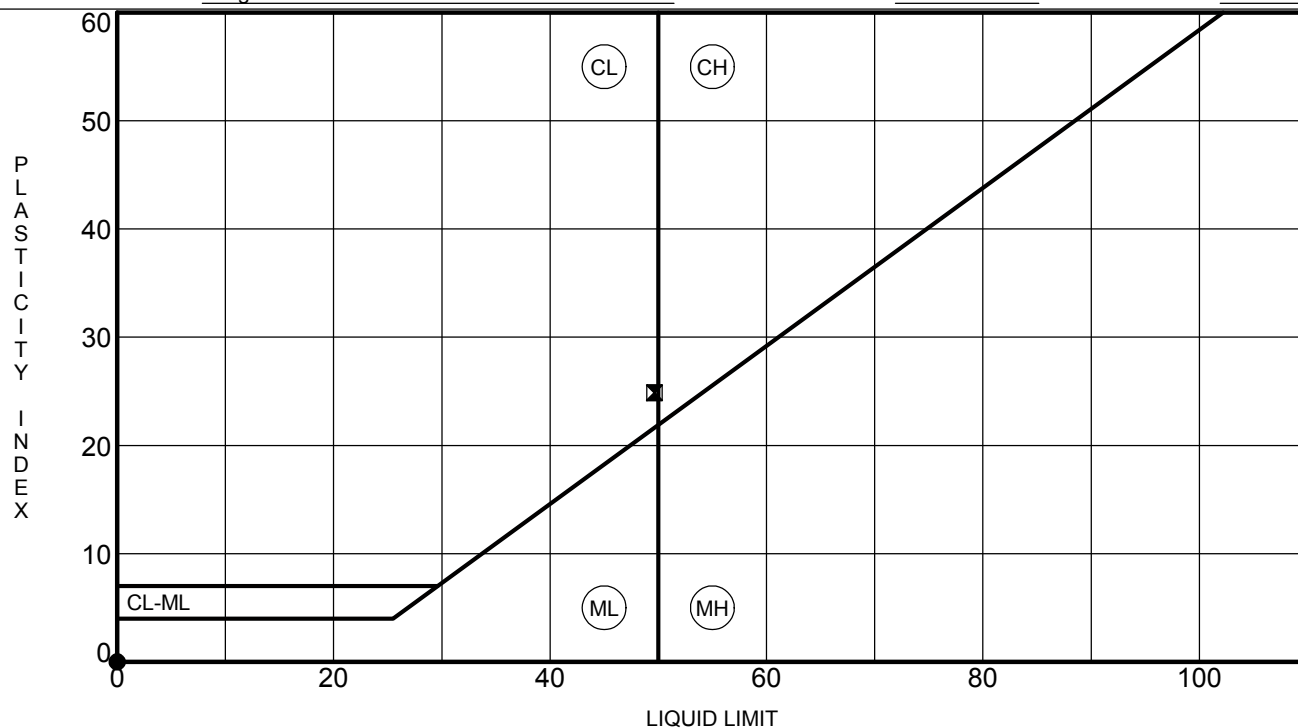
CLIENT Geoconcepts Engineering, Inc.

PROJECT NAME Arkendale-Powell's Creek Third Track

PROJECT LOCATION Virginia

PROJECT NUMBER 16752-0 VA

DATE TESTED 2/10/2016

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Materials and Construction Inspection and Testing
Telephone No. (410) 363-1555
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GRAIN SIZE DISTRIBUTION

TEST METHOD ASTM D422

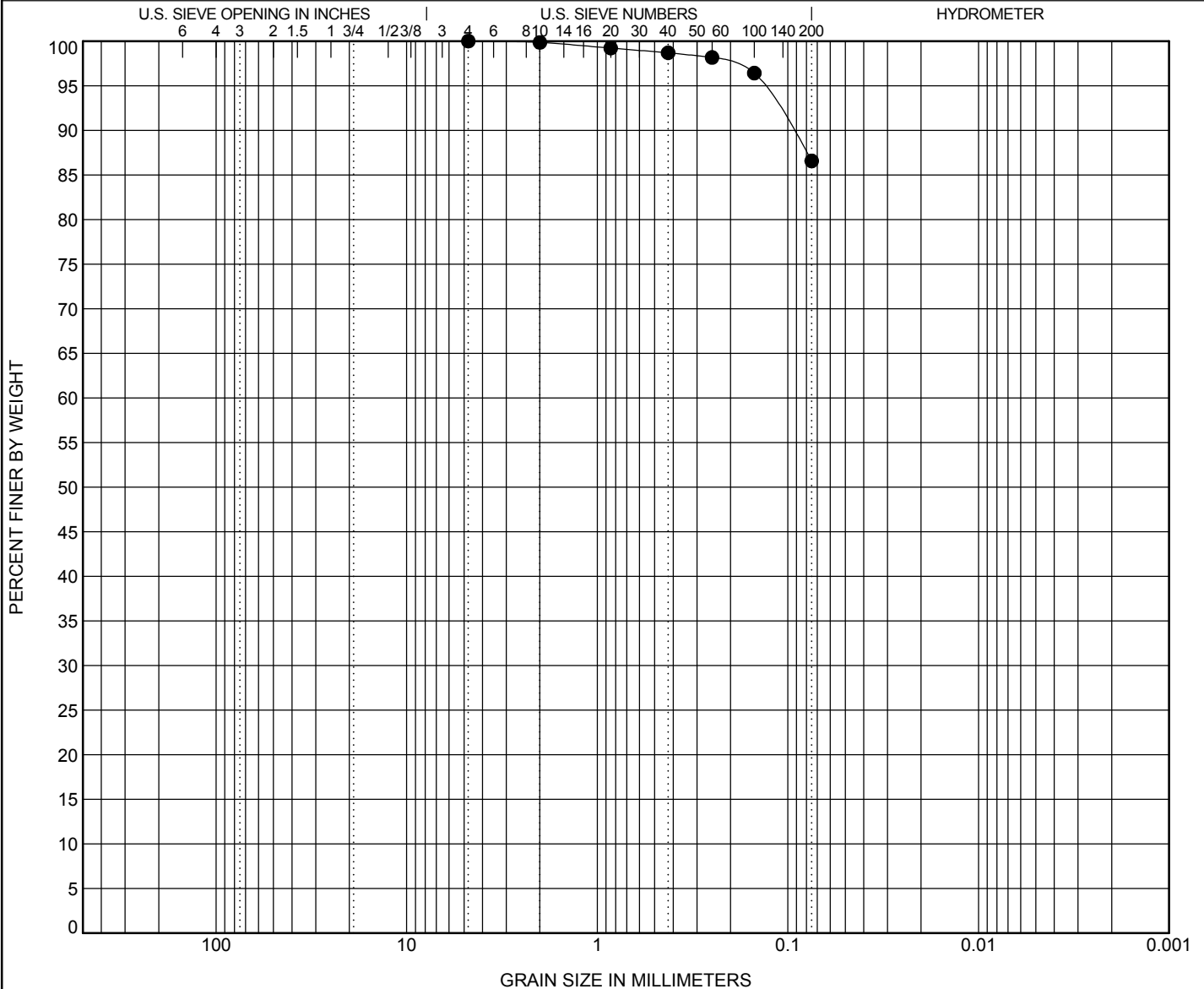
CLIENT Geoconcepts Engineering, Inc.

PROJECT NAME Arkendale-Powell's Creek Third Track

PROJECT LOCATION Virginia

PROJECT NUMBER 16752-0 VA

DATE TESTED 2/10/2016



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

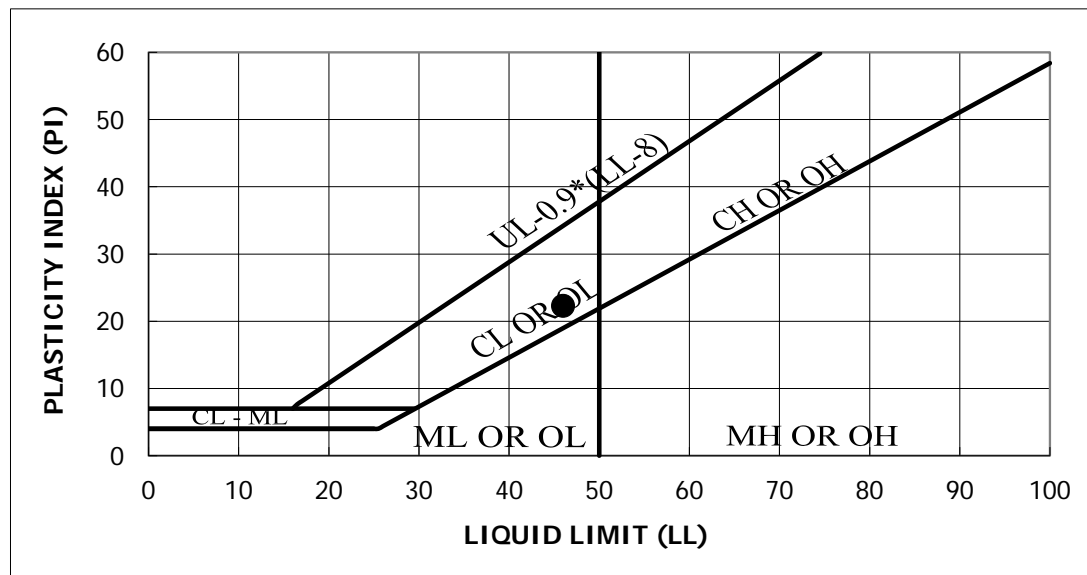
Specimen Identification		Classification					LL	PL	PI	Cc	Cu
● BH-04, Tube @ 28.0' - 30.0',		Mottled Very Dark Greenish Gray, Yellowish Red FAT CLAY(CH)					50	25	25		
Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BH-04, Tube @ 28.0' - 30.0',		4.75				0.0	13.4	86.6			

GRAIN SIZE 16752-0 ARKENDALE-POWELL CREEK THIRD TRACK.GPJ MTA REDLINE.GDT 2/11/16



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-04	Depth (Feet)	33.5'-35.0'
Lab Order No.	3725-10	Date	2/5/2016



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
Lean Clay with sand	46	24	22	100.0	80.7	CL	30.6
Color	Gray		AASHTO Classification		A-7-6		

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Barty

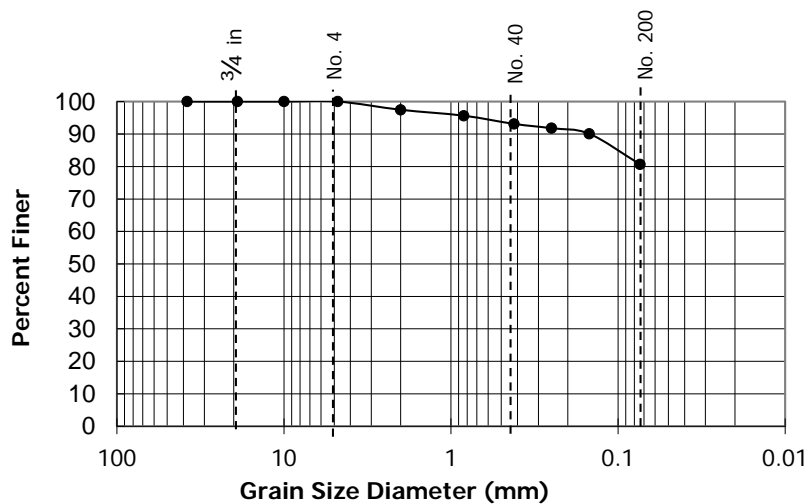


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-04	Depth (Feet)	33.5'-35.0'
Lab Order No.	3725-10	Date	2/5/2016



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	97
#20	96
#40	93
#60	92
#100	90
#200	81
Pan	--

USCS Group Symbol	CL
USCS Group Name	Lean Clay with sand
Cu	---
Cc	---
LL	46
PI	22
Gravel	0.0
Sand	19.3
Fines	80.7
AASHTO Classification	A-7-6
Color	Gray

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

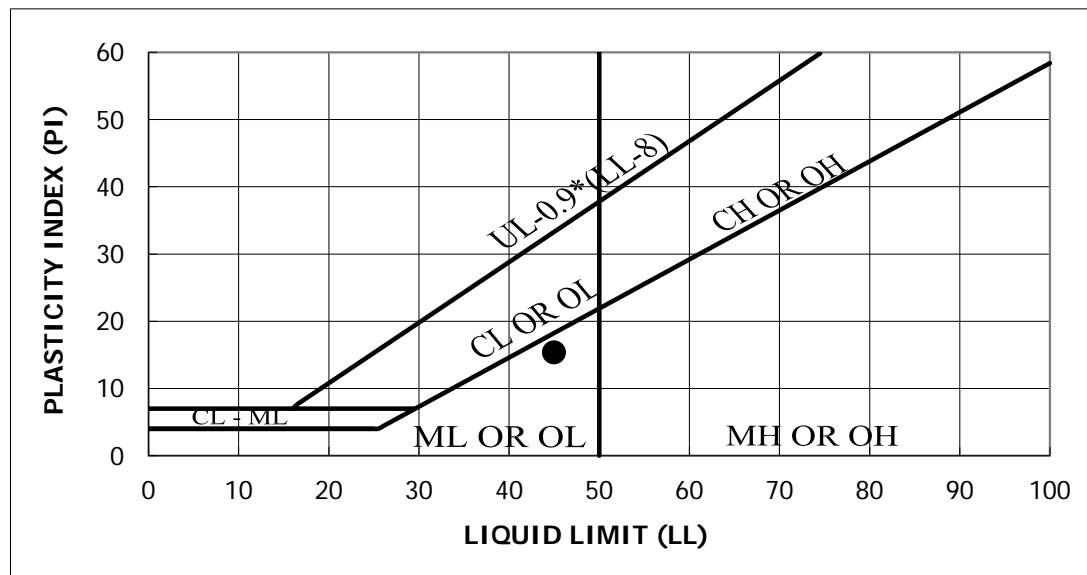
Reviewed by: _____

Lindsay Bantz



LIQUID AND PLASTIC LIMIT - ASTM D4318

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-04	Depth (Feet)	53.5'-55.0'
Lab Order No.	3725-11	Date	2/5/2016



Material Description	LL	PL	PI	% Passing		USCS	w (%)
				#4	#200		
Silt with sand	45	30	15	99.6	77.9	ML	23.1
Color	Brown		AASHTO Classification			A-7-5	

Test Method: ASTM D 4318

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by _____

Reviewed by Lindsay Bantz

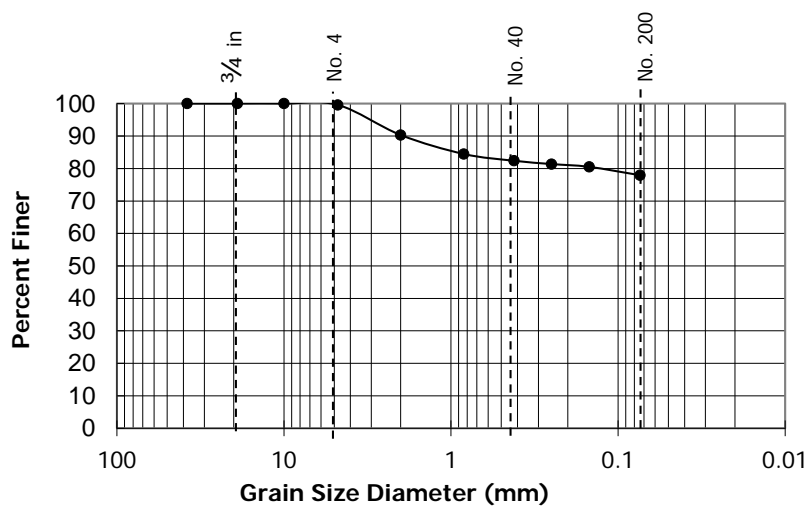


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GRAIN SIZE ANALYSIS - ASTM D422

Project No.	15184	Project Name	Arkendale-Powells Creek Third Track Project
Test Boring No.	BH-04	Depth (Feet)	53.5'-55.0'
Lab Order No.	3725-11	Date	2/5/2016



SIEVE	% Passing
1 1/2 "	100
3/4"	100
3/8"	100
#4	100
#10	90
#20	84
#40	82
#60	81
#100	81
#200	78
Pan	--

USCS Group Symbol	ML
USCS Group Name	Silt with sand
Cu	---
Cc	---
LL	45
PI	15
Gravel	0.4
Sand	21.7
Fines	77.9
AASHTO Classification	A-7-5
Color	Brown

Test Method: ASTM D 422

Soil Classification by ASTM D2487 and AASHTO M 145

Tested by: _____

Reviewed by: _____

Lindsay Bantz



THE ROBERT B. BALTER COMPANY.

*Geotechnical Engineering, Subsurface Exploration
Construction Inspection and Materials Testing*

Unit Weight of Soil

Project: Arkendale-Powell Creek Third Track

Client: GeoConcepts, Inc.

Contract No.: 16752-0 VA

Date: February 10, 016

Boring No.: BH-02

Sample No.: Tube

Depth: 14.0' – 16.0'

Material Description: Brownish Yellow Poorly Graded SAND with Silt (SP-SM)

LL: NP PL: NP PI: NP

Initial Weight: 1042.1 gms.

Average Diameter: 2.854"

Average Height: 6.098"

Natural Moisture: 4.61 %

Wet Unit Weight: 101.7 PCF

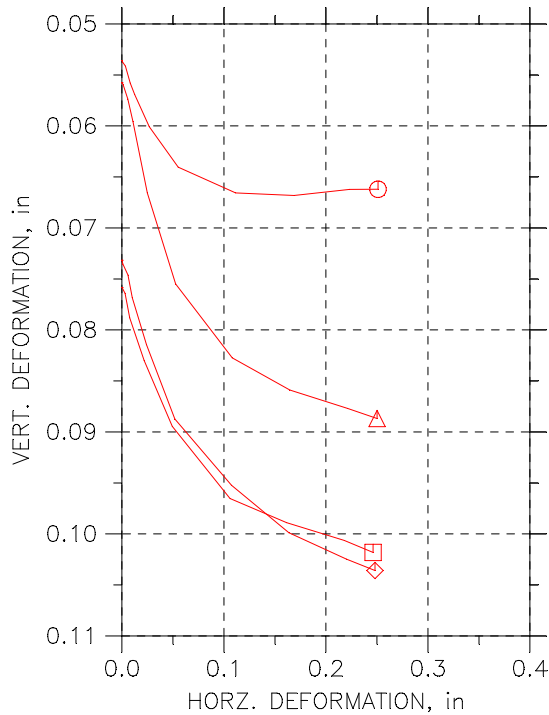
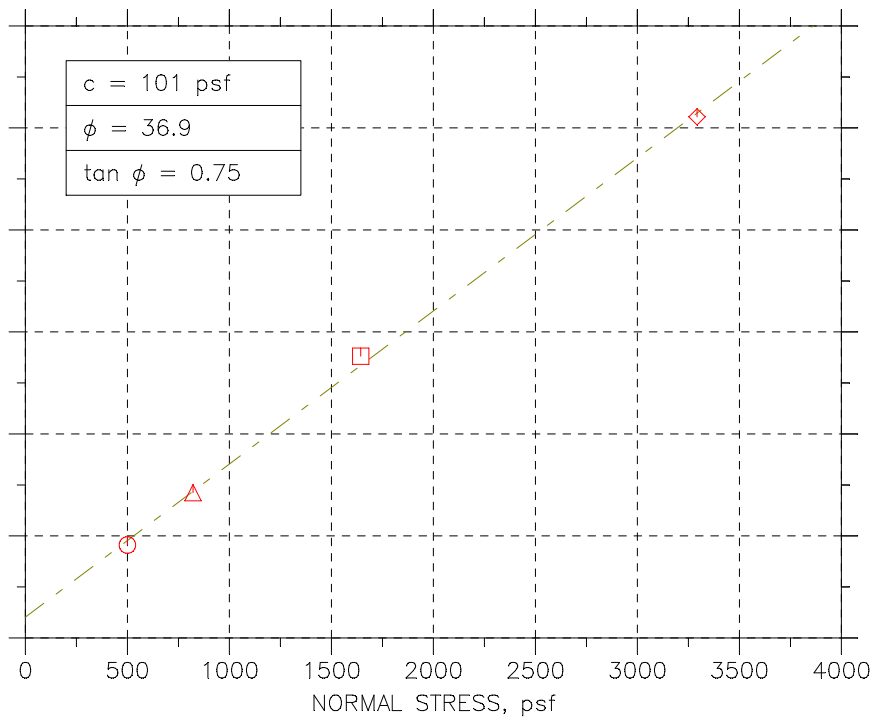
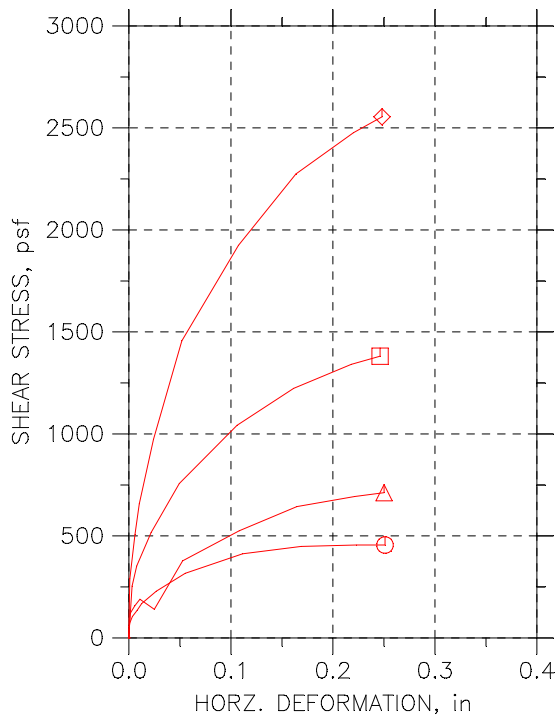
Dry Unit Weight: 97.2 PCF

Alberto R. Bartolome

Alberto R. Bartolome, PG
Laboratory Supervisor



DIRECT SHEAR TEST REPORT



Symbol	⊖	△	□	◇
Test No.	1	2	3	4
Sample No.				
Shape	Circular	Circular	Circular	Circular
Initial	Dimension, in	2.498	2.497	2.5
	Area, in ²	4.9009	4.897	4.9087
	Height, in	0.994	1.002	0.999
	Water Content, %	7.06	7.79	5.77
	Dry Density, pcf	91.105	82.748	87.42
	Saturation, %	21.76	19.79	16.33
	Void Ratio	0.89809	1.0898	0.9781
Consol. Height, in		0.94169	0.94676	0.9234
Consol. Void Ratio		0.79819	0.97456	0.82841
Final	Water Content, %	26.58	27.84	25.45
	Dry Density, pcf	97.607	90.784	97.34
	Saturation, %	95.43	85.22	90.79
	Void Ratio	0.77165	0.90481	0.77651
Normal Stress, psf		499.91	821.94	1643.3
Max. Shear Stress, psf		455.18	711.99	1380.8
Ult. Shear Stress, psf		455.18	711.99	1380.8
Time to Failure, min		8.9535	9.0283	8.9827

Project: Arkendale - Powell's Cree	Disp. Rate, in/min	0.03	0.03	0.03	0.03
Location:	Estimated Specific Gravity	2.77	2.77	2.77	2.77
Project No.: 16752-0 VA	Liquid Limit	NP	NP	NP	NP
Boring No.: BH-02	Plastic Limit	NP	NP	NP	NP
Sample Type: Undisturbed	Plasticity Index	NP	NP	NP	NP
Description: Brownish Yellow Poorly Graded SAND with Silt (SP-SM)					
Remarks: Sample Location: 16681-0 Arkendale - Powell's Creek Third Track Project BH-02 14.0' - 16.0'- 500 PSF					



THE ROBERT B. BALTER COMPANY.

*Geotechnical Engineering, Subsurface Exploration
Construction Inspection and Materials Testing*

Unit Weight of Soil

Project: Arkendale-Powell Creek Third Track

Client: GeoConcepts, Inc.

Contract No.: 16752-0 VA

Date: February 10, 016

Boring No.: BH-04

Sample No.: Tube

Depth: 28.0' – 30.0'

Material Description: Mottled Very Dark Greenish Gray, Yellowish Red Fat CLAY (CH)

LL: 50

PL: 25

PI: 25

Initial Weight: 1460.8 gms.

Average Diameter: 2.849"

Average Height: 7.022"

Natural Moisture: 29.05 %

Wet Unit Weight: 124.2 PCF

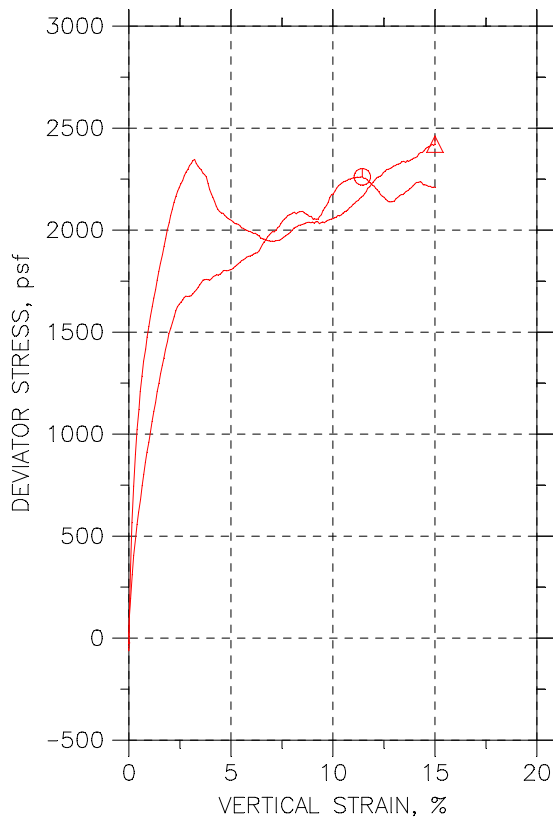
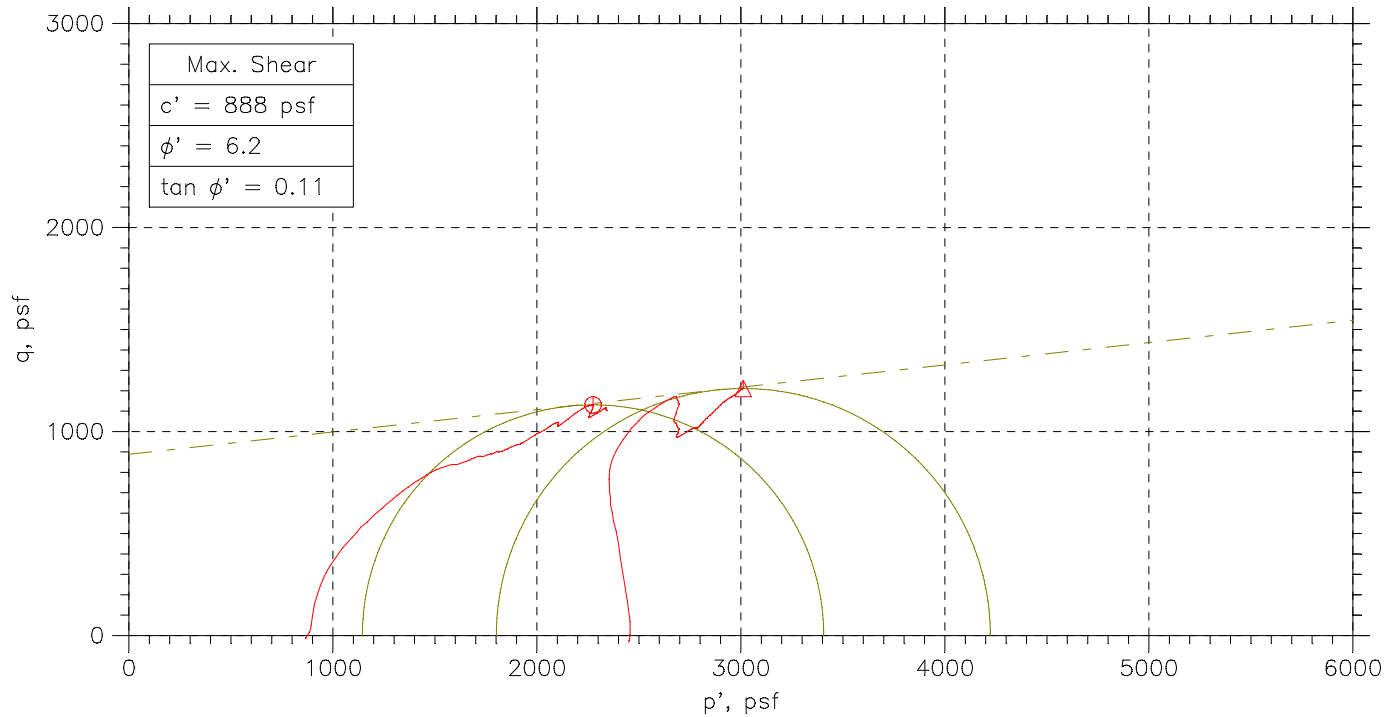
Dry Unit Weight: 96.3 PCF

Alberto R. Bartolome

Alberto R. Bartolome, PG
Laboratory Supervisor



CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



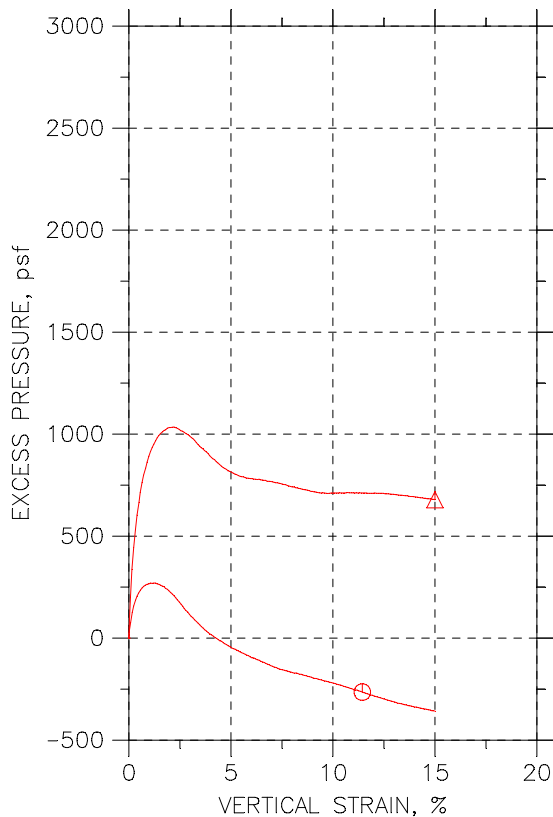
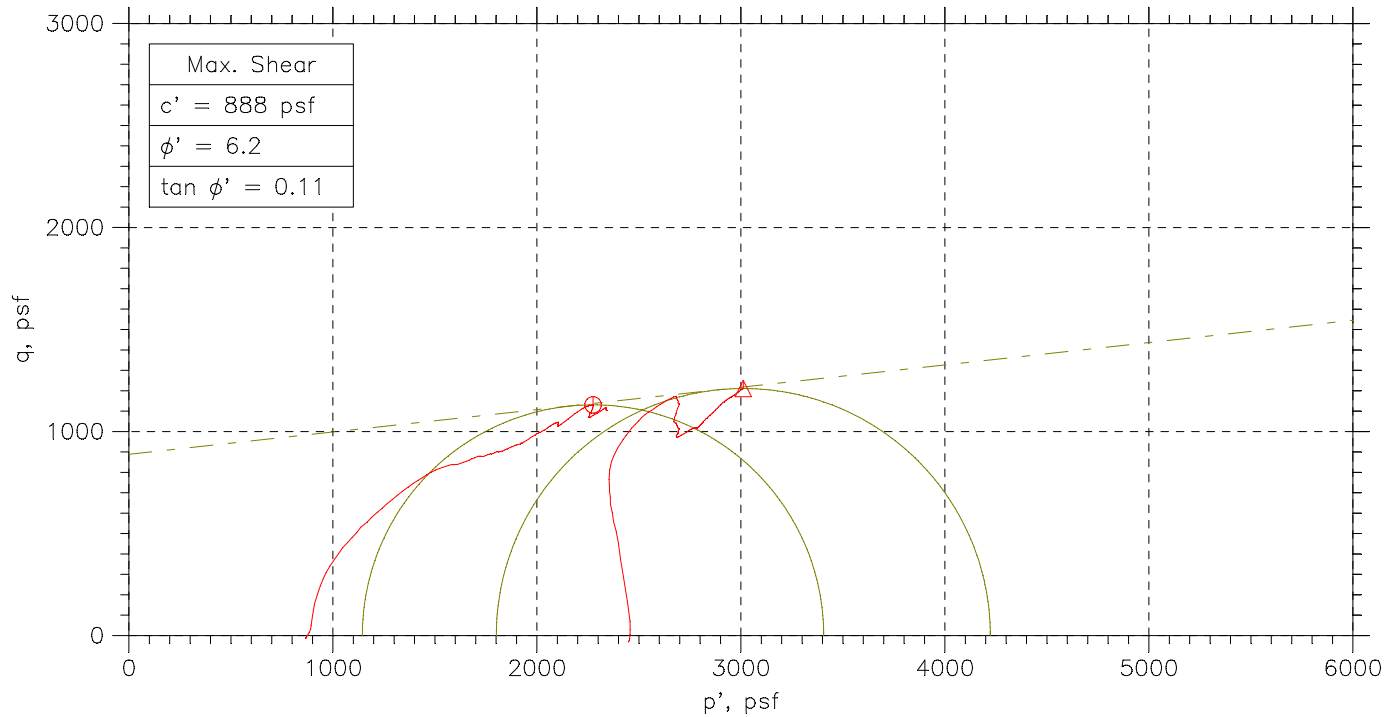
Symbol	⊙	△		
Sample No.				
Test No.	1	2		
Depth	29.0'–29.529.5'–30.0'			
Initial	Diameter, in	2.861	2.882	
	Height, in	5.704	5.687	
	Water Content, %	29.1	32.8	
	Dry Density, pcf	94.08	87.01	
	Saturation, %	99.1	94.5	
	Void Ratio	0.792	0.937	
Before Shear	Water Content, %	33.8	35.6	
	Dry Density, pcf	88.16	85.91	
	Saturation*, %	100.0	100.0	
	Void Ratio	0.912	0.962	
	Back Press., psf	7631	10520	
Ver. Eff. Cons. Stress, psf		878.6	2482	
Shear Strength, psf		1131	1211	
Strain at Failure, %		11.4	15	
Strain Rate, %/min		0.01667	0.01667	
B-Value		0.90	0.90	
Estimated Specific Gravity		2.7	2.7	
Liquid Limit		50	50	
Plastic Limit		25	25	

	Project: Arkendale - Powell's Cree	<div></div>	<div></div>	<div></div>	<div></div>
	Location: Virginia				
	Project No.: 16752-0 VA				
	Boring No.: BH-04				
	Sample Type: Undisturbed				
	Description: Mottled Very Dark Greenish Gray, Yellowish Red Fat CLAY (CH)				
Remarks: 16714-0 Arkendale - Powell's Creek BH-04 28.0' - 30.0' - CU Triaxial - 800 PSF					

Phase calculations based on start of test.

* Saturation is set to 100% for phase calculations

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



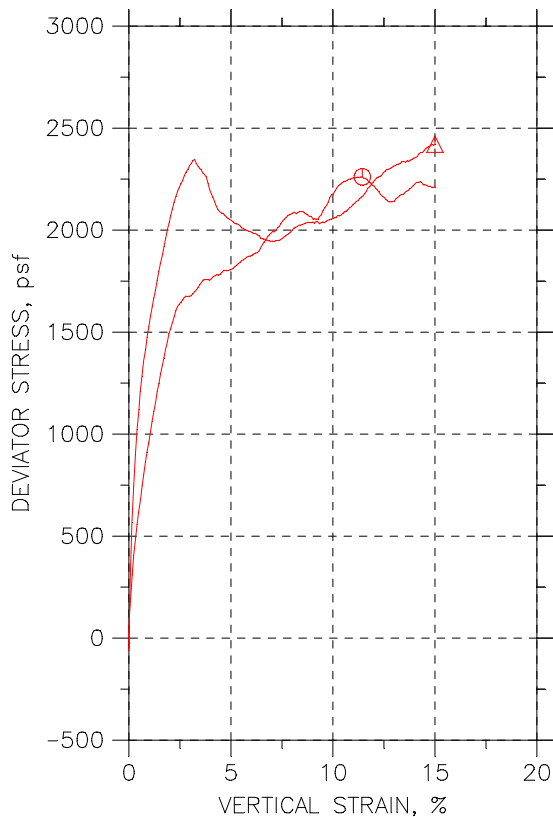
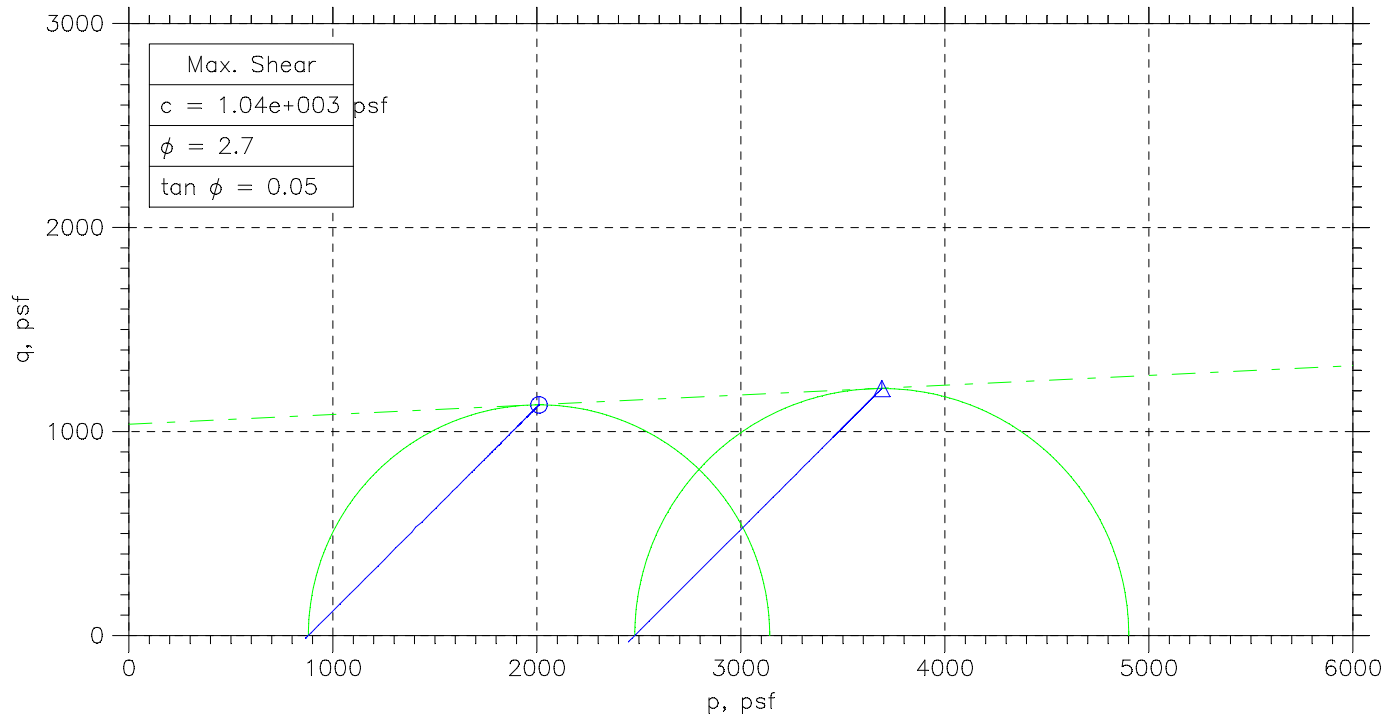
Symbol	⊖	Δ		
Sample No.				
Test No.	1	2		
Depth	29.0'–29.529.5'–30.0'			
Initial	Diameter, in	2.861	2.882	
	Height, in	5.704	5.687	
	Water Content, %	29.1	32.8	
	Dry Density, pcf	94.08	87.01	
	Saturation, %	99.1	94.5	
Before Shear				
	Water Content, %	33.8	35.6	
	Dry Density, pcf	88.16	85.91	
	Saturation*, %	100.0	100.0	
	Void Ratio	0.912	0.962	
	Back Press., psf	7631	10520	
	Ver. Eff. Cons. Stress, psf	878.6	2482	
	Shear Strength, psf	1131	1211	
	Strain at Failure, %	11.4	15	
	Strain Rate, %/min	0.01667	0.01667	
	B-Value	0.90	0.90	
	Estimated Specific Gravity	2.7	2.7	
	Liquid Limit	50	50	
	Plastic Limit	25	25	

	Project: Arkendale - Powell's Cree				
	Location: Virginia				
	Project No.: 16752-0 VA				
	Boring No.: BH-04				
	Sample Type: Undisturbed				
	Description: Mottled Very Dark Greenish Gray, Yellowish Red Fat CLAY (CH)				
	Remarks: 16714-0 Arkendale - Powell's Creek BH-04 28.0' - 30.0' - CU Triaxial - 800 PSF				

Phase calculations based on start of test.

* Saturation is set to 100% for phase calculations

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



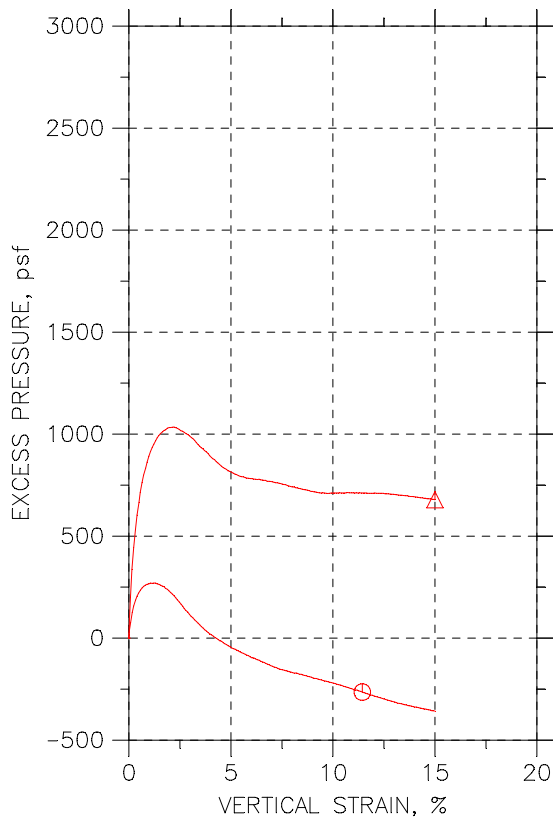
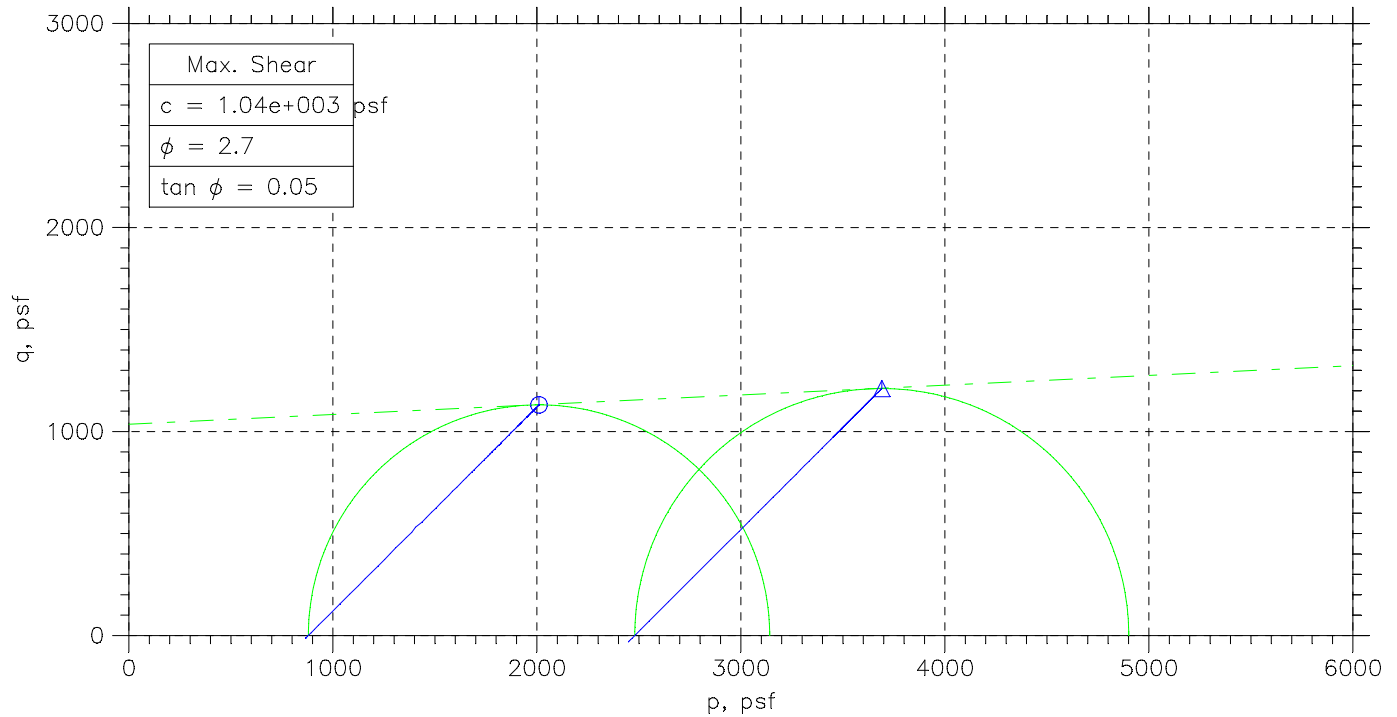
Symbol	⊙	△		
Sample No.				
Test No.	1	2		
Depth	29.0'–29.529.5'–30.0'			
Initial	Diameter, in	2.861	2.882	
	Height, in	5.704	5.687	
	Water Content, %	29.1	32.8	
	Dry Density, pcf	94.08	87.01	
	Saturation, %	99.1	94.5	
	Void Ratio	0.792	0.937	
Before Shear	Water Content, %	33.8	35.6	
	Dry Density, pcf	88.16	85.91	
	Saturation*, %	100.0	100.0	
	Void Ratio	0.912	0.962	
	Back Press., psf	7631	10520	
Ver. Eff. Cons. Stress, psf		878.6	2482	
Shear Strength, psf		1131	1211	
Strain at Failure, %		11.4	15	
Strain Rate, %/min		0.01667	0.01667	
B-Value		0.90	0.90	
Estimated Specific Gravity		2.7	2.7	
Liquid Limit		50	50	
Plastic Limit		25	25	

	Project: Arkendale - Powell's Cree				
	Location: Virginia				
	Project No.: 16752-0 VA				
	Boring No.: BH-04				
	Sample Type: Undisturbed				
	Description: Mottled Very Dark Greenish Gray, Yellowish Red Fat CLAY (CH)				
Remarks: 16714-0 Arkendale - Powell's Creek BH-04 28.0' - 30.0' - CU Triaxial - 800 PSF					


Phase calculations based on start of test.

* Saturation is set to 100% for phase calculations

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



Symbol	⊙	△		
Sample No.				
Test No.	1	2		
Depth	29.0'–29.529.5'–30.0'			
Initial	Diameter, in	2.861	2.882	
	Height, in	5.704	5.687	
	Water Content, %	29.1	32.8	
	Dry Density, pcf	94.08	87.01	
	Saturation, %	99.1	94.5	
Before Shear	Void Ratio	0.792	0.937	
	Water Content, %	33.8	35.6	
	Dry Density, pcf	88.16	85.91	
	Saturation*, %	100.0	100.0	
	Void Ratio	0.912	0.962	
	Back Press., psf	7631	10520	
	Ver. Eff. Cons. Stress, psf	878.6	2482	
	Shear Strength, psf	1131	1211	
	Strain at Failure, %	11.4	15	
	Strain Rate, %/min	0.01667	0.01667	
	B-Value	0.90	0.90	
	Estimated Specific Gravity	2.7	2.7	
	Liquid Limit	50	50	
	Plastic Limit	25	25	

	Project: Arkendale - Powell's Cree	<div></div>	<div></div>	<div></div>	<div></div>
	Location: Virginia				
	Project No.: 16752-0 VA				
	Boring No.: BH-04				
	Sample Type: Undisturbed				
	Description: Mottled Very Dark Greenish Gray, Yellowish Red Fat CLAY (CH)				
Remarks: 16714-0 Arkendale - Powell's Creek BH-04 28.0' - 30.0' - CU Triaxial - 800 PSF					

Phase calculations based on start of test.

* Saturation is set to 100% for phase calculations



Report Number: **163105**

HP ENVIRONMENTAL
INCORPORATED

Page 1 of 2

Certificate of Laboratory Analysis

GeoConcepts Engineering, Inc.
Attn: Fernanda Madrona
19955 Highland Vista Dr.
Suite 170
Ashburn, VA 20147

Date Received: 01/27/16
Date Reported: 01/28/16
Project Location: **Quantico, VA**

1. Client Sample No: **BH-01**
Sample Matrix: Soil
Sample Location: 15' - 20'

HPE Sample No.: 163105-01
Date Collected:

Test(s) Requested: **Soil Corrosion Potential Profile**
Analysis Method(s): Various

Date Analyzed: 01/28/16

<u>Analyte</u>	<u>Result</u>	<u>Units</u>	<u>Reporting Limit</u>	<u>Qualifier</u>
Resistivity - ASTM G187	12000	ohm-cm	N/A	
Redox Potential - Electrode	+ 362	mV	N/A	
pH - CA643	4.7	pH	N/A	
Chloride (Water Soluble) - CA422	6.8	mg/Kg	2.5	
Sulfate (Water Soluble) - CA417	< 5.0	mg/Kg	5.0	U
Sulfide (Water Soluble) EPA 376.2	< 1.2	mg/Kg	1.2	U
Moisture (Percent)	17	%	N/A	

JP

01/28/16

Approved by

Date

Analyte Qualifier Codes

U = Analyte was not detected

Appendix C

Global Stability Results

Table C-1: Soil Design Parameters (1 page)
Global Stability Calculations (84 pages)

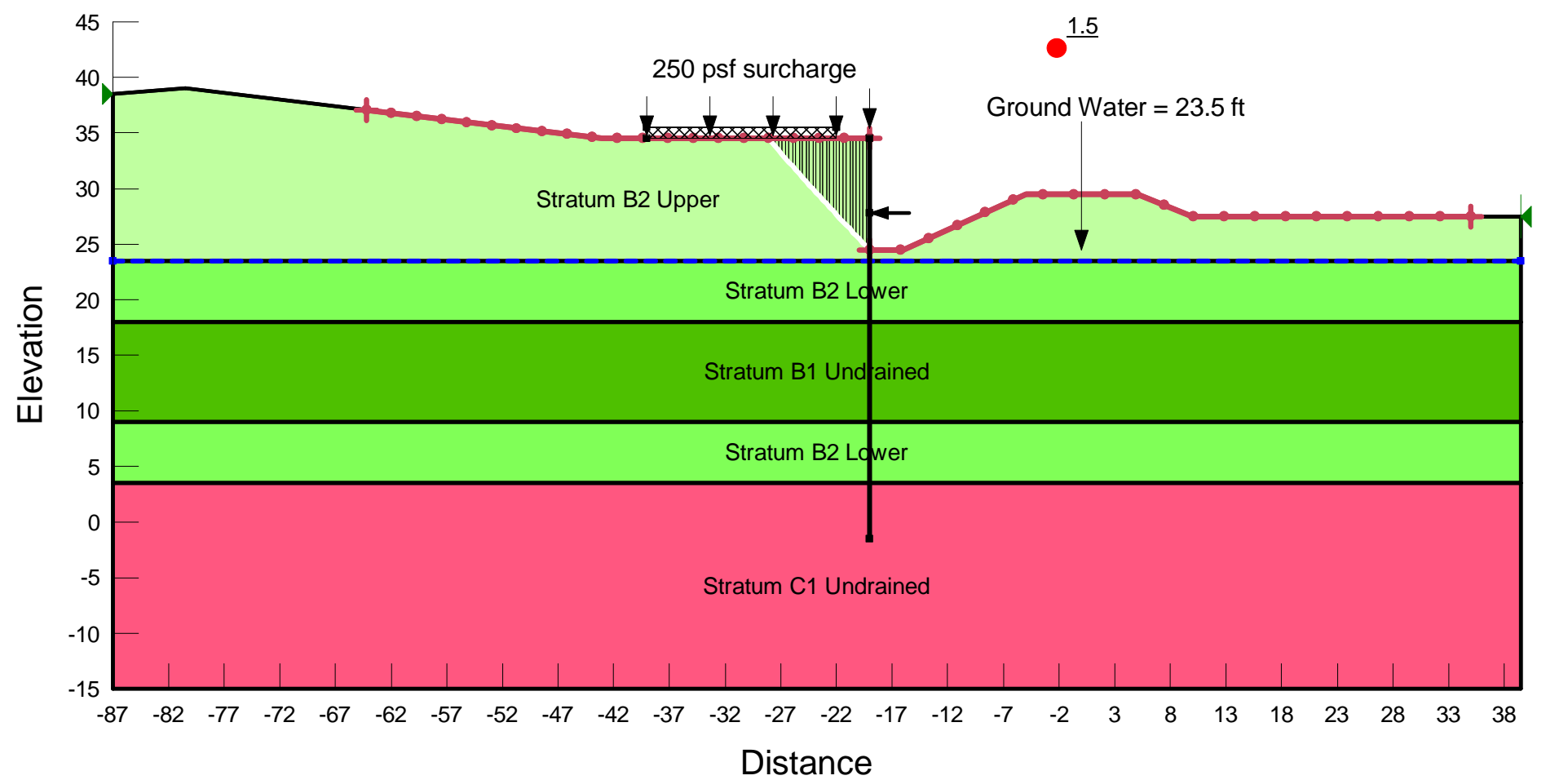
Stratum (Material Description)	Unit Weight, g (pcf)	Short-Term Strength		Long-Term Strength		Lateral Earth Pressure (LEP) Coefficients ^{1,2,3}						Lateral Analyses			Ultimate Bond Strength (psi)
		Cohesion, c (psf) ¹	Friction Angle, f (degrees)	Cohesion, c' (psf) ¹	Friction Angle, f' (degrees)	Active		At-Rest		Passive ⁴		p-y Curve Parameters		Lpile Soil Model ⁹	
						Level Backslope	2H:1V Backslope	Level Backslope	2H:1V Backslope	Level Toe slope	2H:1V Toe slope	Soil Modulus, K (pci) ⁷	Soil Strain E ₅₀ ⁸		
A (CL/ML)	120	1,000	0	50	26	0.39	0.90	0.56	0.90	2.6	1.0	20	0.01	Sand (Reese) or Stiff Clay	N/A
A (SC/SM)	120	0	30	50	30	0.33	0.54	0.50	0.72	3.0	1.9	30	--	Sand (Reese)	N/A
B1 (CL/ML)	120	1,000	0	50	26	0.39	0.90	0.56	0.90	2.6	1.0	25	0.01	Sand (Reese) or Stiff Clay	8.7
B2 (SC/SM), N<10	120	50	28	50	28	0.36	0.65	0.53	0.77	2.8	1.5	30/25	--	Sand (Reese)	13.0
B2 (SC/SM), N>10	125	0	35	0	35	0.27	0.38	0.43	0.62	3.7	2.6	90/60	--	Sand (Reese)	13.0
C1 (CL/ML) – Fully Softened	120	1,000	0	0	23 ^{5,6*}	0.45	N/A	0.61	0.90	2.2	N/A	60/45	0.01	Sand (Reese) or Stiff Clay	8.7
C1 (CH/MH) – Residual Strength	120	1,000	0	0	13 ^{5**}	0.63 [#]	N/A	0.78	N/A	1.6	N/A	&	&	&	8.7
C2 (SC/SM)	125	0	35	0	35	0.27	0.38	0.43	0.62	3.7	2.1	90/60	--	Sand (Reese)	13.0

Notes:

1. Lateral earth pressure coefficients are based on Rankine's equation.
2. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
3. Include traffic, pedestrian, or heavy compaction equipment surcharge pressure when calculating the earth pressures where appropriate.
4. No safety factor is included in these values.
5. *Fully softened friction angle. **Residual friction angle.
6. Fully softened soil properties ranges between 29 degrees and 23 degrees. For the lateral earth pressure a friction angle of 23 degrees is used.
7. K (pci) should be used in long-term condition. First number to use above water table and second number to use below water table.
8. E₅₀ clay model should be used in short-term condition.
9. Use stiff clay model for undrained condition (short-term) and Sand (Reese) model for drained condition (long-term).
 & Use from Fully softened soil parameters.

Arkendale to Powells Creek Third Track Project
Soldier Pile Wall - Global Stability Analysis
Station 8263+00 Undrained
Section A-A'

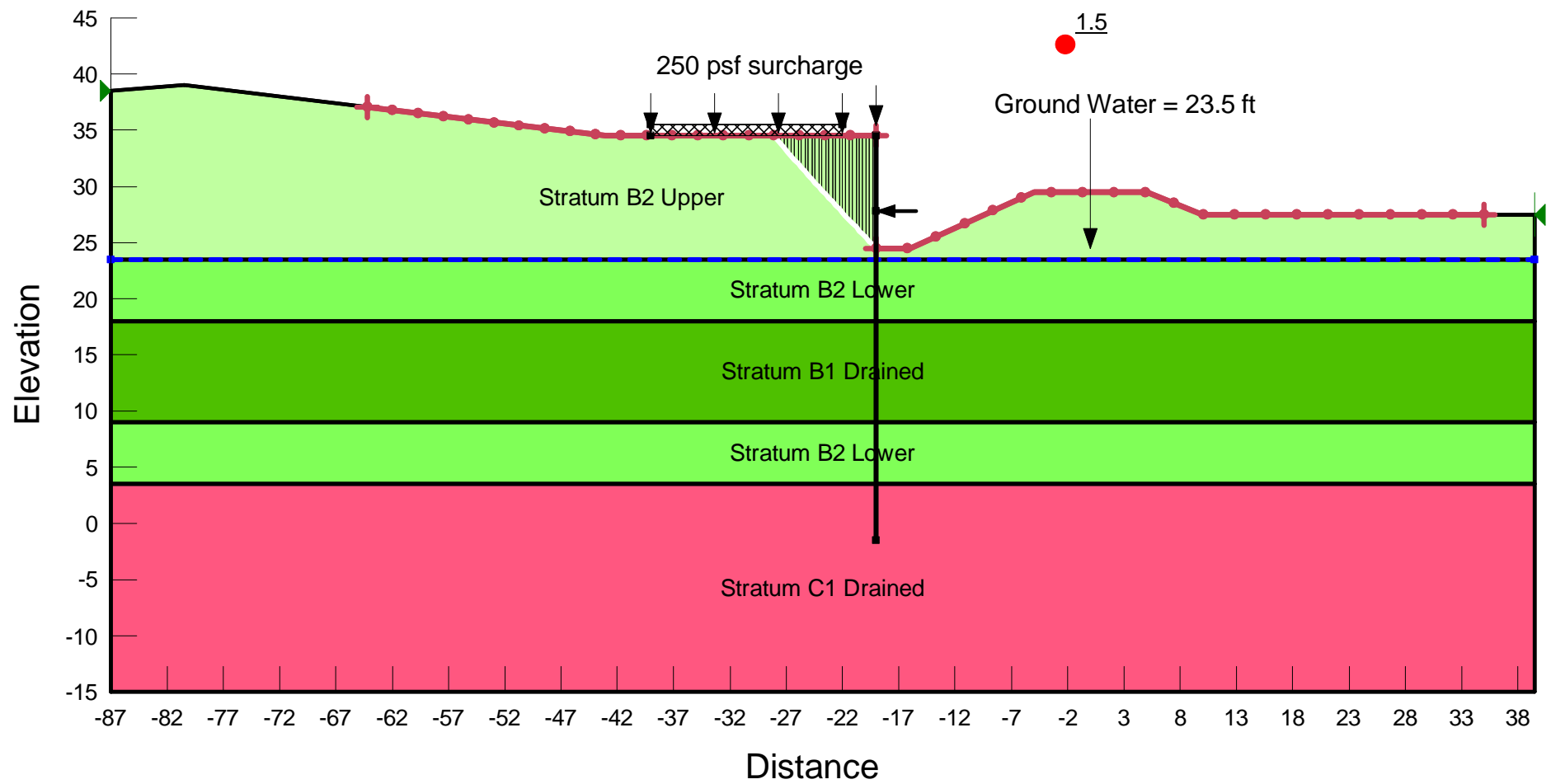
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
<div></div>	Stratum B1 Undrained	Mohr-Coulomb	120	1,000	0
<div></div>	Stratum B2 Lower	Mohr-Coulomb	125	0	35
<div></div>	Stratum B2 Upper	Mohr-Coulomb	125	50	28
<div></div>	Stratum C1 Undrained	Mohr-Coulomb	120	1,000	0



Units for Distance and Elevation are in feet.

Arkendale to Powells Creek Third Track Project
Soldier Pile Wall - Global Stability Analysis
Station 8263+00 Drained
Section A-A'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
<div></div>	Stratum B1 Drained	Mohr-Coulomb	120	50	26
<div></div>	Stratum B2 Lower	Mohr-Coulomb	125	0	35
<div></div>	Stratum B2 Upper	Mohr-Coulomb	125	50	28
<div></div>	Stratum C1 Drained	Mohr-Coulomb	120	0	13



Units for Distance and Elevation are in feet.

8263+00 Undrained

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File Information

File Version: 9.00
Title: Section A-A
Created By: Ali Alqazzaz
Last Edited By: Garden, Alistair S
Revision Number: 91
Date: 06/05/2020
Time: 08:09:53 AM
Tool Version: 9.0.3.15488
File Name: SECTION A-A' (8263+00).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 06/05/2020
Last Solved Time: 08:10:16 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8263+00 Undrained

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Stratum B2 Upper

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B2 Lower

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B1 Undrained

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 1,000 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum C1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion: [1,000 psf](#)
Phi: [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-64.21098, 37.04532\) ft](#)
Left-Zone Right Coordinate: [\(-19, 34.5\) ft](#)
Left-Zone Increment: [20](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-19, 24.5\) ft](#)
Right-Zone Right Coordinate: [\(35, 27.5\) ft](#)
Right-Zone Increment: [20](#)
Radius Increments: [10](#)

Slip Surface Limits

Left Coordinate: [\(-87, 38.5\) ft](#)
Right Coordinate: [\(39.5, 27.5\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-87 ft	23.5 ft
Coordinate 2	39.5 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Pile](#)
Outside Point: [\(-19, 34.5\) ft](#)
Inside Point: [\(-19, -1.5\) ft](#)
Slip Surface Intersection: [\(-19, 24.5\) ft](#)
Length: [36 ft](#)
Direction: [90 °](#)
Shear Force: [1,100 lbf](#)

Shear Reduction Factor: [1](#)
Pile Spacing: [1 ft](#)
Apply Shear: [Parallel to Slip](#)
Shear Force Applied: [1,100 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)

Point Loads

Point Load 1

Coordinate: [\(-19, 27.833\) ft](#)
Magnitude: [2,200 lbf](#)
Direction: [360 °](#)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): [250 pcf](#)
Direction: [Vertical](#)

Coordinates

	X	Y
	-39 ft	34.5 ft
	-39 ft	35.5 ft
	-22 ft	35.5 ft

Points

	X	Y
Point 1	-19 ft	34.5 ft
Point 2	-43 ft	34.5 ft
Point 3	-80.5 ft	39 ft
Point 4	-16 ft	24.5 ft
Point 5	-5 ft	29.5 ft
Point 6	5 ft	29.5 ft
Point 7	20 ft	27.5 ft
Point 8	10 ft	27.5 ft
Point 9	-87 ft	38.5 ft
Point 10	39.5 ft	27.5 ft
Point 11	39.5 ft	-15 ft
Point 12	-87 ft	-15 ft
Point 13	-19 ft	24.5 ft
Point 14	39.5 ft	23.5 ft

Point 15	-87 ft	23.5 ft
Point 16	-87 ft	18 ft
Point 17	39.5 ft	18 ft
Point 18	-87 ft	9 ft
Point 19	39.5 ft	9 ft
Point 20	-87 ft	3.5 ft
Point 21	39.5 ft	3.5 ft

Regions

	Material	Points	Area
Region 1	Stratum C1 Undrained	12,11,21,20	2,340.3 ft²
Region 2	Stratum B2 Upper	10,7,8,6,5,4,13,1,2,3,9,15,14	1,104.5 ft²
Region 3	Stratum B2 Lower	14,15,16,17	695.75 ft²
Region 4	Stratum B1 Undrained	17,16,18,19	1,138.5 ft²
Region 5	Stratum B2 Lower	19,18,20,21	695.75 ft²

Current Slip Surface

Slip Surface: 3,697
Factor of Safety: 1.5
Volume: 46.534907 ft³
Weight: 5,816.8633 lbf
Resisting Moment: 734,312.82 lbf-ft
Activating Moment: 488,876.37 lbf-ft
Resisting Force: 2,842.9475 lbf
Activating Force: 1,892.7214 lbf
Slip Rank: 1 of 4,851 slip surfaces
Exit: (-19, 24.5) ft
Entry: (-28.072631, 34.5) ft
Radius: 174.95149 ft
Center: (105.93861, 146.96782) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-27.920815 ft	34.319598 ft	-675.14291 psf	159.61924 psf	84.871057 psf	50 psf
Slice 2	-27.617183 ft	33.959776 ft	-652.69003 psf	181.46916 psf	96.488863 psf	50 psf

Slice 3	-27.313552 ft	33.60191 ft	-630.35916 psf	201.53306 psf	107.15703 psf	50 psf
Slice 4	-27.00992 ft	33.24598 ft	-608.14915 psf	220.34866 psf	117.16146 psf	50 psf
Slice 5	-26.706289 ft	32.891969 ft	-586.05886 psf	238.41029 psf	126.765 psf	50 psf
Slice 6	-26.402657 ft	32.539859 ft	-564.0872 psf	256.17165 psf	136.20888 psf	50 psf
Slice 7	-26.099026 ft	32.189632 ft	-542.23305 psf	274.05122 psf	145.71562 psf	50 psf
Slice 8	-25.795394 ft	31.841272 ft	-520.49536 psf	292.43895 psf	155.49255 psf	50 psf
Slice 9	-25.491763 ft	31.494761 ft	-498.87307 psf	311.70351 psf	165.7357 psf	50 psf
Slice 10	-25.188131 ft	31.150082 ft	-477.36514 psf	332.19958 psf	176.63365 psf	50 psf
Slice 11	-24.8845 ft	30.80722 ft	-455.97055 psf	354.27488 psf	188.3713 psf	50 psf
Slice 12	-24.580868 ft	30.466159 ft	-434.68831 psf	378.2767 psf	201.13329 psf	50 psf
Slice 13	-24.277237 ft	30.126882 ft	-413.51743 psf	404.55786 psf	215.10723 psf	50 psf
Slice 14	-23.973605 ft	29.789374 ft	-392.45694 psf	433.4821 psf	230.48652 psf	50 psf
Slice 15	-23.669973 ft	29.45362 ft	-371.50589 psf	465.42861 psf	247.47278 psf	50 psf
Slice 16	-23.366342 ft	29.119605 ft	-350.66334 psf	500.79581 psf	266.27785 psf	50 psf
Slice 17	-23.06271 ft	28.787314 ft	-329.92839 psf	540.00394 psf	287.12519 psf	50 psf
Slice 18	-22.759079 ft	28.456733 ft	-309.30011 psf	583.49636 psf	310.25052 psf	50 psf
Slice 19	-22.455447 ft	28.127847 ft	-288.77762 psf	631.73883 psf	335.90149 psf	50 psf
Slice 20	-22.151816 ft	27.800642 ft	-268.36005 psf	685.21649 psf	364.33607 psf	50 psf
Slice 21	-21.85 ft	27.477042 ft	-248.1674 psf	599.01552 psf	318.5022 psf	50 psf
Slice 22	-21.55 ft	27.157013 ft	-228.19759 psf	658.38053 psf	350.06714 psf	50 psf
Slice 23	-21.25 ft	26.838586 ft	-208.32774 psf	723.14254 psf	384.50171 psf	50 psf
Slice 24	-20.95 ft	26.521748 ft	-188.55704 psf	793.7138 psf	422.02511 psf	50 psf
Slice 25	-20.65 ft	26.206486 ft	-168.88473 psf	870.45008 psf	462.82652 psf	50 psf
Slice 26	-20.35 ft	25.892789 ft	-149.31001 psf	953.61788 psf	507.04762 psf	50 psf

Slice 27	-20.05 ft	25.580644 ft	-129.83216 psf	1,043.3522 psf	554.76021 psf	50 psf
Slice 28	-19.75 ft	25.270039 ft	-110.4504 psf	1,139.6041 psf	605.93823 psf	50 psf
Slice 29	-19.45 ft	24.960962 ft	-91.164023 psf	1,242.0772 psf	660.42416 psf	50 psf
Slice 30	-19.15 ft	24.653402 ft	-71.972293 psf	-574.92446 psf	-305.69276 psf	50 psf

8263+00 Drained

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File Information

File Version: 9.00
Title: Section A-A
Created By: Ali Alqazzaz
Last Edited By: Garden, Alistair S
Revision Number: 89
Date: 06/04/2020
Time: 04:49:19 PM
Tool Version: 9.0.3.15488
File Name: SECTION A-A' (8263+00).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 06/04/2020
Last Solved Time: 04:49:34 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8263+00 Drained
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Stratum B2 Upper
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B2 Lower
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B1 Drained
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum C1 Drained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion: [0 psf](#)
Phi: [13 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-64.21098, 37.04532\) ft](#)
Left-Zone Right Coordinate: [\(-19, 34.5\) ft](#)
Left-Zone Increment: [20](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-19, 24.5\) ft](#)
Right-Zone Right Coordinate: [\(35, 27.5\) ft](#)
Right-Zone Increment: [20](#)
Radius Increments: [10](#)

Slip Surface Limits

Left Coordinate: [\(-87, 38.5\) ft](#)
Right Coordinate: [\(39.5, 27.5\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-87 ft	23.5 ft
Coordinate 2	39.5 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Pile](#)
Outside Point: [\(-19, 34.5\) ft](#)
Inside Point: [\(-19, -1.5\) ft](#)
Slip Surface Intersection: [\(-19, 24.5\) ft](#)
Length: [36 ft](#)
Direction: [90 °](#)
Shear Force: [1,100 lbf](#)

Shear Reduction Factor: [1](#)
Pile Spacing: [1 ft](#)
Apply Shear: [Parallel to Slip](#)
Shear Force Applied: [1,100 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)

Point Loads

Point Load 1

Coordinate: [\(-19, 27.833\) ft](#)
Magnitude: [2,200 lbf](#)
Direction: [360 °](#)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): [250 pcf](#)
Direction: [Vertical](#)

Coordinates

	X	Y
	-39 ft	34.5 ft
	-39 ft	35.5 ft
	-22 ft	35.5 ft

Points

	X	Y
Point 1	-19 ft	34.5 ft
Point 2	-43 ft	34.5 ft
Point 3	-80.5 ft	39 ft
Point 4	-16 ft	24.5 ft
Point 5	-5 ft	29.5 ft
Point 6	5 ft	29.5 ft
Point 7	20 ft	27.5 ft
Point 8	10 ft	27.5 ft
Point 9	-87 ft	38.5 ft
Point 10	39.5 ft	27.5 ft
Point 11	39.5 ft	-15 ft
Point 12	-87 ft	-15 ft
Point 13	-19 ft	24.5 ft
Point 14	39.5 ft	23.5 ft

Point 15	-87 ft	23.5 ft
Point 16	-87 ft	18 ft
Point 17	39.5 ft	18 ft
Point 18	-87 ft	9 ft
Point 19	39.5 ft	9 ft
Point 20	-87 ft	3.5 ft
Point 21	39.5 ft	3.5 ft

Regions

	Material	Points	Area
Region 1	Stratum C1 Drained	12,11,21,20	2,340.3 ft²
Region 2	Stratum B2 Upper	10,7,8,6,5,4,13,1,2,3,9,15,14	1,104.5 ft²
Region 3	Stratum B2 Lower	14,15,16,17	695.75 ft²
Region 4	Stratum B1 Drained	17,16,18,19	1,138.5 ft²
Region 5	Stratum B2 Lower	19,18,20,21	695.75 ft²

Current Slip Surface

Slip Surface: 3,697
Factor of Safety: 1.5
Volume: 46.534907 ft³
Weight: 5,816.8633 lbf
Resisting Moment: 734,312.82 lbf-ft
Activating Moment: 488,876.37 lbf-ft
Resisting Force: 2,842.9475 lbf
Activating Force: 1,892.7214 lbf
Slip Rank: 1 of 4,851 slip surfaces
Exit: (-19, 24.5) ft
Entry: (-28.072631, 34.5) ft
Radius: 174.95149 ft
Center: (105.93861, 146.96782) ft

Slip Slices

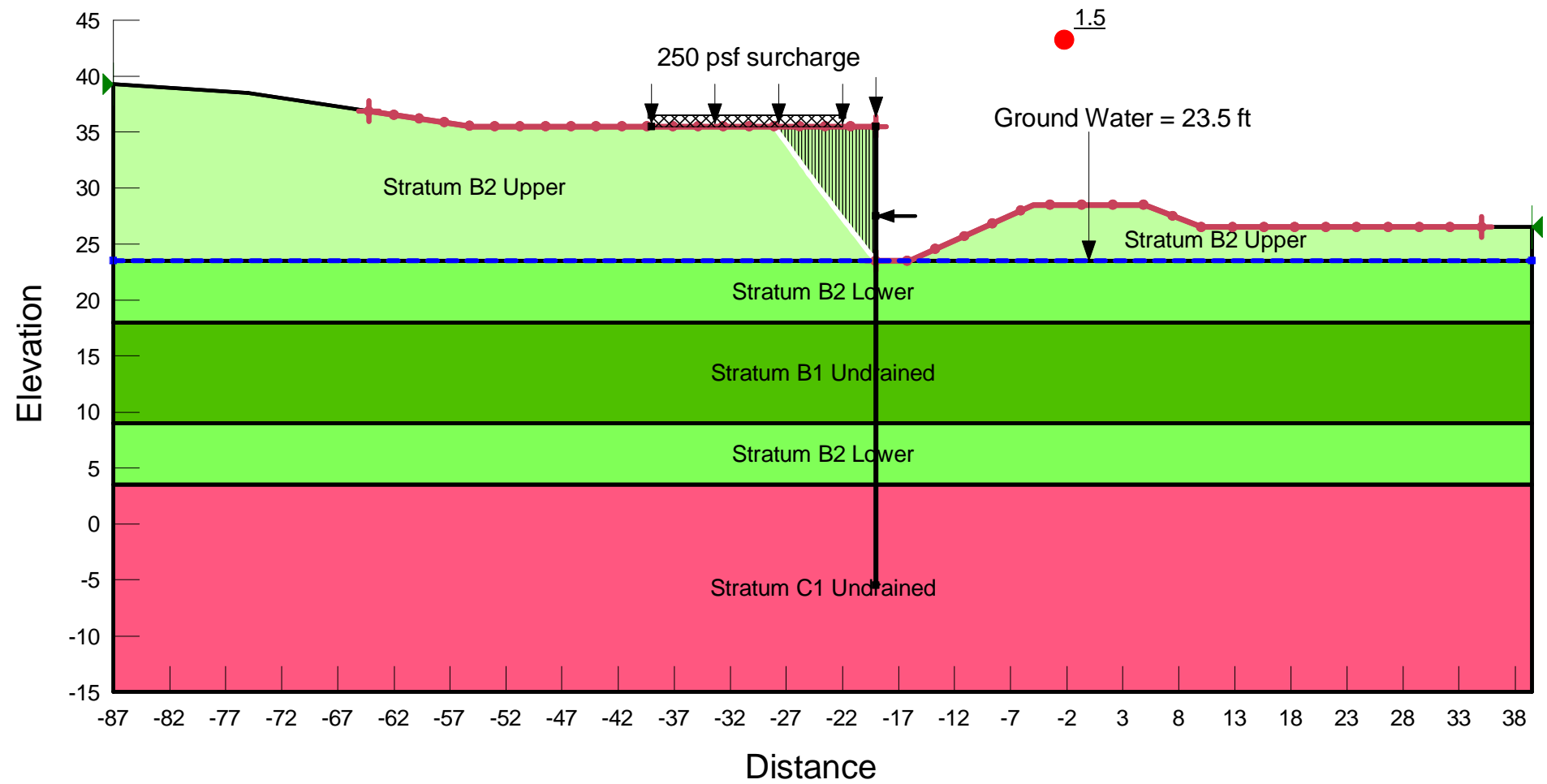
	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-27.920815 ft	34.319598 ft	-675.14291 psf	159.61924 psf	84.871057 psf	50 psf
Slice 2	-27.617183 ft	33.959776 ft	-652.69003 psf	181.46916 psf	96.488863 psf	50 psf

Slice 3	-27.313552 ft	33.60191 ft	-630.35916 psf	201.53306 psf	107.15703 psf	50 psf
Slice 4	-27.00992 ft	33.24598 ft	-608.14915 psf	220.34866 psf	117.16146 psf	50 psf
Slice 5	-26.706289 ft	32.891969 ft	-586.05886 psf	238.41029 psf	126.765 psf	50 psf
Slice 6	-26.402657 ft	32.539859 ft	-564.0872 psf	256.17165 psf	136.20888 psf	50 psf
Slice 7	-26.099026 ft	32.189632 ft	-542.23305 psf	274.05122 psf	145.71562 psf	50 psf
Slice 8	-25.795394 ft	31.841272 ft	-520.49536 psf	292.43895 psf	155.49255 psf	50 psf
Slice 9	-25.491763 ft	31.494761 ft	-498.87307 psf	311.70351 psf	165.7357 psf	50 psf
Slice 10	-25.188131 ft	31.150082 ft	-477.36514 psf	332.19958 psf	176.63365 psf	50 psf
Slice 11	-24.8845 ft	30.80722 ft	-455.97055 psf	354.27488 psf	188.3713 psf	50 psf
Slice 12	-24.580868 ft	30.466159 ft	-434.68831 psf	378.2767 psf	201.13329 psf	50 psf
Slice 13	-24.277237 ft	30.126882 ft	-413.51743 psf	404.55786 psf	215.10723 psf	50 psf
Slice 14	-23.973605 ft	29.789374 ft	-392.45694 psf	433.4821 psf	230.48652 psf	50 psf
Slice 15	-23.669973 ft	29.45362 ft	-371.50589 psf	465.42861 psf	247.47278 psf	50 psf
Slice 16	-23.366342 ft	29.119605 ft	-350.66334 psf	500.79581 psf	266.27785 psf	50 psf
Slice 17	-23.06271 ft	28.787314 ft	-329.92839 psf	540.00394 psf	287.12519 psf	50 psf
Slice 18	-22.759079 ft	28.456733 ft	-309.30011 psf	583.49636 psf	310.25052 psf	50 psf
Slice 19	-22.455447 ft	28.127847 ft	-288.77762 psf	631.73883 psf	335.90149 psf	50 psf
Slice 20	-22.151816 ft	27.800642 ft	-268.36005 psf	685.21649 psf	364.33607 psf	50 psf
Slice 21	-21.85 ft	27.477042 ft	-248.1674 psf	599.01552 psf	318.5022 psf	50 psf
Slice 22	-21.55 ft	27.157013 ft	-228.19759 psf	658.38053 psf	350.06714 psf	50 psf
Slice 23	-21.25 ft	26.838586 ft	-208.32774 psf	723.14254 psf	384.50171 psf	50 psf
Slice 24	-20.95 ft	26.521748 ft	-188.55704 psf	793.7138 psf	422.02511 psf	50 psf
Slice 25	-20.65 ft	26.206486 ft	-168.88473 psf	870.45008 psf	462.82652 psf	50 psf
Slice 26	-20.35 ft	25.892789 ft	-149.31001 psf	953.61788 psf	507.04762 psf	50 psf

Slice 27	-20.05 ft	25.580644 ft	-129.83216 psf	1,043.3522 psf	554.76021 psf	50 psf
Slice 28	-19.75 ft	25.270039 ft	-110.4504 psf	1,139.6041 psf	605.93823 psf	50 psf
Slice 29	-19.45 ft	24.960962 ft	-91.164023 psf	1,242.0772 psf	660.42416 psf	50 psf
Slice 30	-19.15 ft	24.653402 ft	-71.972293 psf	-574.92446 psf	-305.69276 psf	50 psf

Arkendale to Powells Creek Third Track Project
Soldier Pile Wall - Global Stability Analysis
Station 8264+00 Undrained
Section A-A'

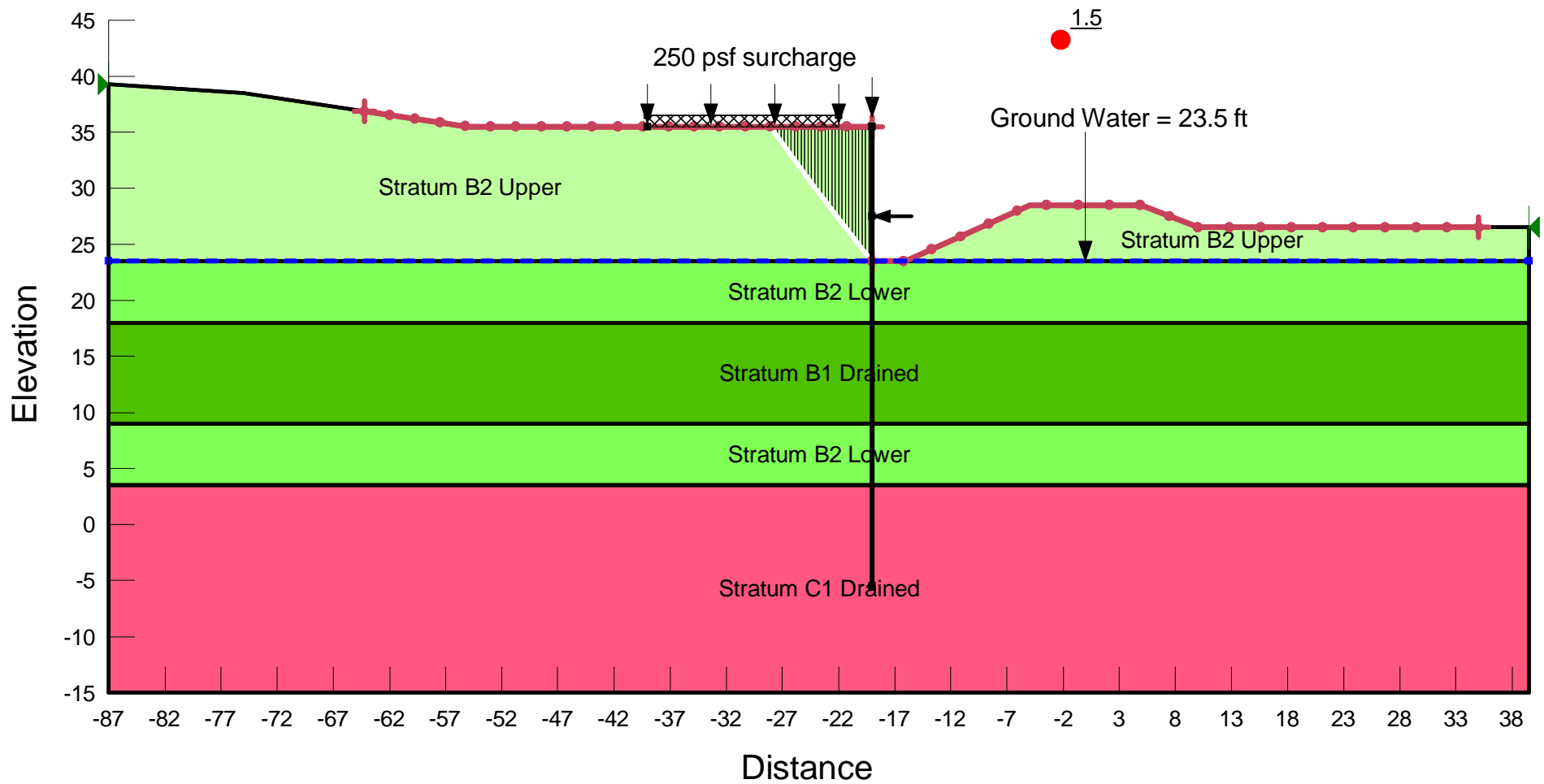
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
<div></div>	Stratum B1 Undrained	Mohr-Coulomb	120	1,000	0
<div></div>	Stratum B2 Lower	Mohr-Coulomb	125	0	35
<div></div>	Stratum B2 Upper	Mohr-Coulomb	125	50	28
<div></div>	Stratum C1 Undrained	Mohr-Coulomb	120	1,000	0



Units for Distance and Elevation are in feet.

Arkendale to Powells Creek Third Track Project
 Soldier Pile Wall - Global Stability Analysis
 Station 8264+00 Drained
 Section A-A'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
■	Stratum B1 Drained	Mohr-Coulomb	120	50	26
■	Stratum B2 Lower	Mohr-Coulomb	125	0	35
■	Stratum B2 Upper	Mohr-Coulomb	125	50	28
■	Stratum C1 Drained	Mohr-Coulomb	120	0	13



Units for Distance and Elevation are in feet.

8264+00 Undrained

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File Information

File Version: 9.00
Title: Section A-A
Created By: Ali Alqazzaz
Last Edited By: Garden, Alistair S
Revision Number: 90
Date: 06/05/2020
Time: 08:24:53 AM
Tool Version: 9.0.3.15488
File Name: SECTION A-A' (8264+00).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 06/05/2020
Last Solved Time: 08:25:17 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8264+00 Undrained

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Stratum B2 Upper

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B2 Lower

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B1 Undrained

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 1,000 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum C1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion: [1,000 psf](#)
Phi: [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-64.22005, 36.883007\) ft](#)
Left-Zone Right Coordinate: [\(-19, 35.5\) ft](#)
Left-Zone Increment: [20](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-19, 23.5\) ft](#)
Right-Zone Right Coordinate: [\(35, 26.5\) ft](#)
Right-Zone Increment: [20](#)
Radius Increments: [10](#)

Slip Surface Limits

Left Coordinate: [\(-87, 39.3\) ft](#)
Right Coordinate: [\(39.5, 26.5\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-87 ft	23.5 ft
Coordinate 2	39.5 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Pile](#)
Outside Point: [\(-19, 35.503567\) ft](#)
Inside Point: [\(-19, -5.503437\) ft](#)
Slip Surface Intersection: [\(-19, 23.5\) ft](#)
Length: [41.007004 ft](#)
Direction: [90 °](#)
Shear Force: [1,500 lbf](#)

Shear Reduction Factor: [1](#)
Pile Spacing: [1 ft](#)
Apply Shear: [Parallel to Slip](#)
Shear Force Applied: [1,500 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)

Point Loads

Point Load 1

Coordinate: [\(-19, 27.5\) ft](#)
Magnitude: [3,200 lbf](#)
Direction: [360 °](#)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): [250 pcf](#)
Direction: [Vertical](#)

Coordinates

	X	Y
	-39 ft	35.5 ft
	-39 ft	36.5 ft
	-22 ft	36.5 ft

Points

	X	Y
Point 1	-19 ft	35.5 ft
Point 2	-55 ft	35.5 ft
Point 3	-75 ft	38.5 ft
Point 4	-16 ft	23.5 ft
Point 5	-5 ft	28.5 ft
Point 6	5 ft	28.5 ft
Point 7	20 ft	26.5 ft
Point 8	10 ft	26.5 ft
Point 9	-87 ft	39.3 ft
Point 10	-87 ft	23.5 ft
Point 11	39.5 ft	26.5 ft
Point 12	39.5 ft	23.5 ft
Point 13	39.5 ft	-15 ft
Point 14	-87 ft	-15 ft

Point 15	-19 ft	23.5 ft
Point 16	-87 ft	18 ft
Point 17	39.5 ft	18 ft
Point 18	-87 ft	9 ft
Point 19	39.5 ft	9 ft
Point 20	-87 ft	3.5 ft
Point 21	39.5 ft	3.5 ft

Regions

	Material	Points	Area
Region 1	Stratum C1 Undrained	14,13,21,20	2,340.3 ft²
Region 2	Stratum B2 Upper	1,2,3,9,10,15	886.8 ft²
Region 3	Stratum B2 Upper	11,7,8,6,5,4,12	186 ft²
Region 4	Stratum B2 Lower	12,4,15,10,16,17	695.75 ft²
Region 5	Stratum B1 Undrained	17,16,18,19	1,138.5 ft²
Region 6	Stratum B2 Lower	19,18,20,21	695.75 ft²

Current Slip Surface

Slip Surface: 3,697
Factor of Safety: 1.5
Volume: 55.650193 ft³
Weight: 6,956.2741 lbf
Resisting Moment: 1,091,470.6 lbf-ft
Activating Moment: 732,497.93 lbf-ft
Resisting Force: 2,960.5575 lbf
Activating Force: 1,985.8672 lbf
Slip Rank: 1 of 4,851 slip surfaces
Exit: (-19, 23.5) ft
Entry: (-28.06464, 35.5) ft
Radius: 224.35995 ft
Center: (155.39112, 164.65638) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-27.913024 ft	35.285178 ft	-735.39508 psf	146.87928 psf	78.097097 psf	50 psf
				170.05647 psf	90.420629 psf	50 psf

Slice 2	-27.609792 ft	34.856596 ft	-708.6516 psf			
Slice 3	-27.30656 ft	34.430131 ft	-682.04019 psf	190.82937 psf	101.46577 psf	50 psf
Slice 4	-27.003328 ft	34.005762 ft	-655.55957 psf	209.95279 psf	111.63388 psf	50 psf
Slice 5	-26.700096 ft	33.583469 ft	-629.20845 psf	228.08812 psf	121.27661 psf	50 psf
Slice 6	-26.396864 ft	33.163231 ft	-602.9856 psf	245.81804 psf	130.70377 psf	50 psf
Slice 7	-26.093632 ft	32.745029 ft	-576.88978 psf	263.66235 psf	140.19176 psf	50 psf
Slice 8	-25.7904 ft	32.328843 ft	-550.9198 psf	282.09366 psf	149.99186 psf	50 psf
Slice 9	-25.487168 ft	31.914655 ft	-525.07446 psf	301.552 psf	160.33804 psf	50 psf
Slice 10	-25.183936 ft	31.502446 ft	-499.35261 psf	322.4585 psf	171.45422 psf	50 psf
Slice 11	-24.880704 ft	31.092197 ft	-473.7531 psf	345.22775 psf	183.56085 psf	50 psf
Slice 12	-24.577472 ft	30.683891 ft	-448.27481 psf	370.2793 psf	196.881 psf	50 psf
Slice 13	-24.27424 ft	30.27751 ft	-422.91663 psf	398.04827 psf	211.64602 psf	50 psf
Slice 14	-23.971008 ft	29.873037 ft	-397.67748 psf	428.99536 psf	228.10088 psf	50 psf
Slice 15	-23.667776 ft	29.470453 ft	-372.55629 psf	463.61632 psf	246.50917 psf	50 psf
Slice 16	-23.364544 ft	29.069744 ft	-347.552 psf	502.45106 psf	267.15797 psf	50 psf
Slice 17	-23.061312 ft	28.670891 ft	-322.66359 psf	546.09218 psf	290.36236 psf	50 psf
Slice 18	-22.75808 ft	28.273879 ft	-297.89003 psf	595.19294 psf	316.4697 psf	50 psf
Slice 19	-22.454848 ft	27.878691 ft	-273.23033 psf	650.47415 psf	345.86324 psf	50 psf
Slice 20	-22.151616 ft	27.485313 ft	-248.68351 psf	712.72941 psf	378.96495 psf	50 psf
Slice 21	-21.85 ft	27.095805 ft	-224.37822 psf	653.53269 psf	347.4895 psf	50 psf
Slice 22	-21.55 ft	26.710134 ft	-200.31234 psf	725.80668 psf	385.91826 psf	50 psf
Slice 23	-21.25 ft	26.326189 ft	-176.35417 psf	806.28574 psf	428.70973 psf	50 psf
Slice 24	-20.95 ft	25.943955 ft	-152.50279 psf	895.91616 psf	476.36707 psf	50 psf
Slice 25	-20.65 ft	25.563419 ft	-128.75733 psf	995.66214 psf	529.40295 psf	50 psf

Slice 26	-20.35 ft	25.184566 ft	-105.11693 psf	1,106.4692 psf	588.3201 psf	50 psf
Slice 27	-20.05 ft	24.807383 ft	-81.580726 psf	1,229.2088 psf	653.5819 psf	50 psf
Slice 28	-19.75 ft	24.431857 ft	-58.147882 psf	1,364.5988 psf	725.57003 psf	50 psf
Slice 29	-19.45 ft	24.057974 ft	-34.817569 psf	1,513.0931 psf	804.52586 psf	50 psf
Slice 30	-19.15 ft	23.685721 ft	-11.588971 psf	-1,023.3135 psf	-544.10545 psf	50 psf

8264+00 Drained

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File Information

File Version: 9.00
Title: Section A-A
Created By: Ali Alqazzaz
Last Edited By: Garden, Alistair S
Revision Number: 90
Date: 06/05/2020
Time: 08:24:53 AM
Tool Version: 9.0.3.15488
File Name: SECTION A-A' (8264+00).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 06/05/2020
Last Solved Time: 08:25:07 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8264+00 Drained
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Stratum B2 Upper
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B2 Lower
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B1 Drained
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum C1 Drained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion: [0 psf](#)
Phi: [13 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-64.22005, 36.883007\) ft](#)
Left-Zone Right Coordinate: [\(-19, 35.5\) ft](#)
Left-Zone Increment: [20](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-19, 23.5\) ft](#)
Right-Zone Right Coordinate: [\(35, 26.5\) ft](#)
Right-Zone Increment: [20](#)
Radius Increments: [10](#)

Slip Surface Limits

Left Coordinate: [\(-87, 39.3\) ft](#)
Right Coordinate: [\(39.5, 26.5\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-87 ft	23.5 ft
Coordinate 2	39.5 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Pile](#)
Outside Point: [\(-19, 35.503567\) ft](#)
Inside Point: [\(-19, -5.503437\) ft](#)
Slip Surface Intersection: [\(-19, 23.5\) ft](#)
Length: [41.007004 ft](#)
Direction: [90 °](#)
Shear Force: [1,500 lbf](#)

Shear Reduction Factor: [1](#)
Pile Spacing: [1 ft](#)
Apply Shear: [Parallel to Slip](#)
Shear Force Applied: [1,500 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)

Point Loads

Point Load 1

Coordinate: [\(-19, 27.5\) ft](#)
Magnitude: [3,200 lbf](#)
Direction: [360 °](#)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): [250 pcf](#)
Direction: [Vertical](#)

Coordinates

	X	Y
	-39 ft	35.5 ft
	-39 ft	36.5 ft
	-22 ft	36.5 ft

Points

	X	Y
Point 1	-19 ft	35.5 ft
Point 2	-55 ft	35.5 ft
Point 3	-75 ft	38.5 ft
Point 4	-16 ft	23.5 ft
Point 5	-5 ft	28.5 ft
Point 6	5 ft	28.5 ft
Point 7	20 ft	26.5 ft
Point 8	10 ft	26.5 ft
Point 9	-87 ft	39.3 ft
Point 10	-87 ft	23.5 ft
Point 11	39.5 ft	26.5 ft
Point 12	39.5 ft	23.5 ft
Point 13	39.5 ft	-15 ft
Point 14	-87 ft	-15 ft

Point 15	-19 ft	23.5 ft
Point 16	-87 ft	18 ft
Point 17	39.5 ft	18 ft
Point 18	-87 ft	9 ft
Point 19	39.5 ft	9 ft
Point 20	-87 ft	3.5 ft
Point 21	39.5 ft	3.5 ft

Regions

	Material	Points	Area
Region 1	Stratum C1 Drained	14,13,21,20	2,340.3 ft²
Region 2	Stratum B2 Upper	1,2,3,9,10,15	886.8 ft²
Region 3	Stratum B2 Upper	11,7,8,6,5,4,12	186 ft²
Region 4	Stratum B2 Lower	12,4,15,10,16,17	695.75 ft²
Region 5	Stratum B1 Drained	17,16,18,19	1,138.5 ft²
Region 6	Stratum B2 Lower	19,18,20,21	695.75 ft²

Current Slip Surface

Slip Surface: 3,697
Factor of Safety: 1.5
Volume: 55.650193 ft³
Weight: 6,956.2741 lbf
Resisting Moment: 1,091,470.6 lbf-ft
Activating Moment: 732,497.93 lbf-ft
Resisting Force: 2,960.5575 lbf
Activating Force: 1,985.8672 lbf
Slip Rank: 1 of 4,851 slip surfaces
Exit: (-19, 23.5) ft
Entry: (-28.06464, 35.5) ft
Radius: 224.35995 ft
Center: (155.39112, 164.65638) ft

Slip Slices

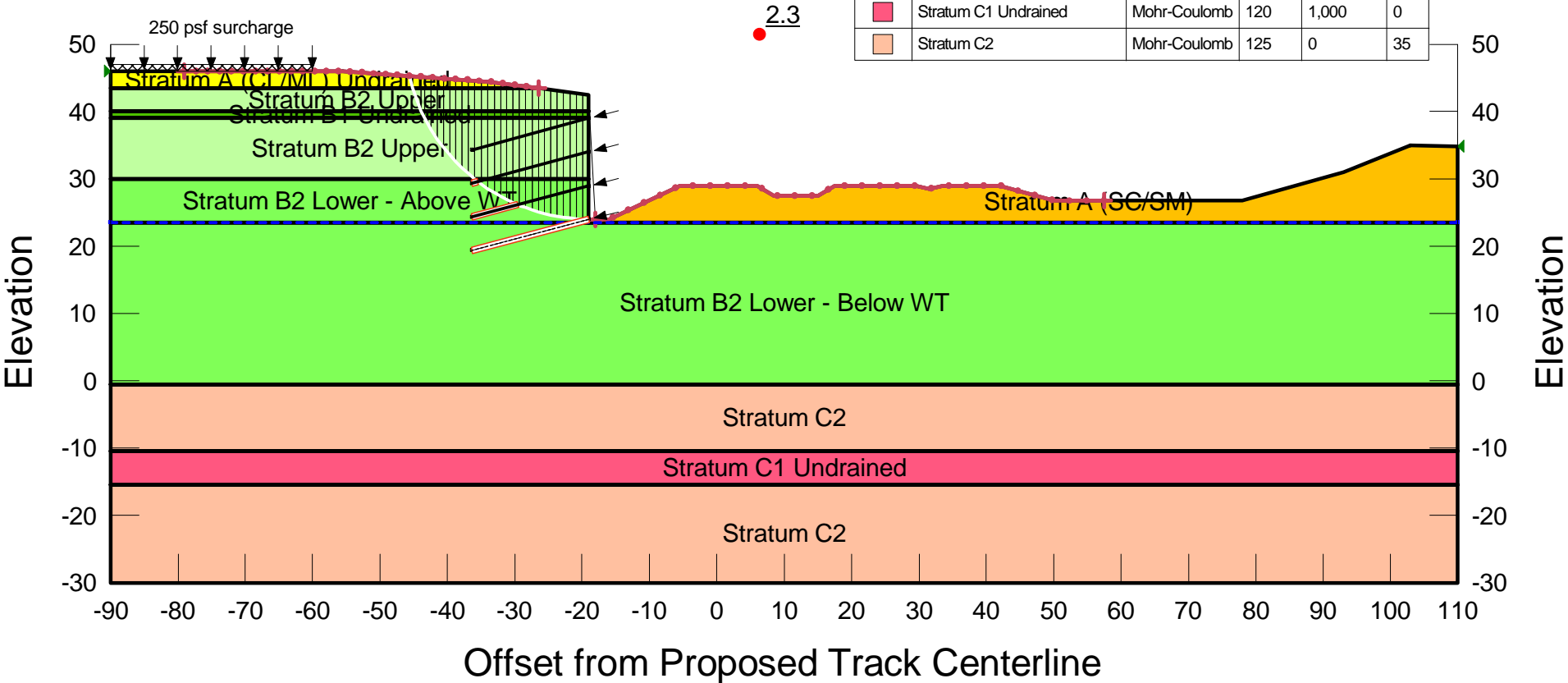
	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-27.913024 ft	35.285178 ft	-735.39508 psf	146.87928 psf	78.097097 psf	50 psf
				170.05647 psf	90.420629 psf	50 psf

Slice 2	-27.609792 ft	34.856596 ft	-708.6516 psf			
Slice 3	-27.30656 ft	34.430131 ft	-682.04019 psf	190.82937 psf	101.46577 psf	50 psf
Slice 4	-27.003328 ft	34.005762 ft	-655.55957 psf	209.95279 psf	111.63388 psf	50 psf
Slice 5	-26.700096 ft	33.583469 ft	-629.20845 psf	228.08812 psf	121.27661 psf	50 psf
Slice 6	-26.396864 ft	33.163231 ft	-602.9856 psf	245.81804 psf	130.70377 psf	50 psf
Slice 7	-26.093632 ft	32.745029 ft	-576.88978 psf	263.66235 psf	140.19176 psf	50 psf
Slice 8	-25.7904 ft	32.328843 ft	-550.9198 psf	282.09366 psf	149.99186 psf	50 psf
Slice 9	-25.487168 ft	31.914655 ft	-525.07446 psf	301.552 psf	160.33804 psf	50 psf
Slice 10	-25.183936 ft	31.502446 ft	-499.35261 psf	322.4585 psf	171.45422 psf	50 psf
Slice 11	-24.880704 ft	31.092197 ft	-473.7531 psf	345.22775 psf	183.56085 psf	50 psf
Slice 12	-24.577472 ft	30.683891 ft	-448.27481 psf	370.2793 psf	196.881 psf	50 psf
Slice 13	-24.27424 ft	30.27751 ft	-422.91663 psf	398.04827 psf	211.64602 psf	50 psf
Slice 14	-23.971008 ft	29.873037 ft	-397.67748 psf	428.99536 psf	228.10088 psf	50 psf
Slice 15	-23.667776 ft	29.470453 ft	-372.55629 psf	463.61632 psf	246.50917 psf	50 psf
Slice 16	-23.364544 ft	29.069744 ft	-347.552 psf	502.45106 psf	267.15797 psf	50 psf
Slice 17	-23.061312 ft	28.670891 ft	-322.66359 psf	546.09218 psf	290.36236 psf	50 psf
Slice 18	-22.75808 ft	28.273879 ft	-297.89003 psf	595.19294 psf	316.4697 psf	50 psf
Slice 19	-22.454848 ft	27.878691 ft	-273.23033 psf	650.47415 psf	345.86324 psf	50 psf
Slice 20	-22.151616 ft	27.485313 ft	-248.68351 psf	712.72941 psf	378.96495 psf	50 psf
Slice 21	-21.85 ft	27.095805 ft	-224.37822 psf	653.53269 psf	347.4895 psf	50 psf
Slice 22	-21.55 ft	26.710134 ft	-200.31234 psf	725.80668 psf	385.91826 psf	50 psf
Slice 23	-21.25 ft	26.326189 ft	-176.35417 psf	806.28574 psf	428.70973 psf	50 psf
Slice 24	-20.95 ft	25.943955 ft	-152.50279 psf	895.91616 psf	476.36707 psf	50 psf
Slice 25	-20.65 ft	25.563419 ft	-128.75733 psf	995.66214 psf	529.40295 psf	50 psf

Slice 26	-20.35 ft	25.184566 ft	-105.11693 psf	1,106.4692 psf	588.3201 psf	50 psf
Slice 27	-20.05 ft	24.807383 ft	-81.580726 psf	1,229.2088 psf	653.5819 psf	50 psf
Slice 28	-19.75 ft	24.431857 ft	-58.147882 psf	1,364.5988 psf	725.57003 psf	50 psf
Slice 29	-19.45 ft	24.057974 ft	-34.817569 psf	1,513.0931 psf	804.52586 psf	50 psf
Slice 30	-19.15 ft	23.685721 ft	-11.588971 psf	-1,023.3135 psf	-544.10545 psf	50 psf

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8265+50, Short Term
 Section B-B'

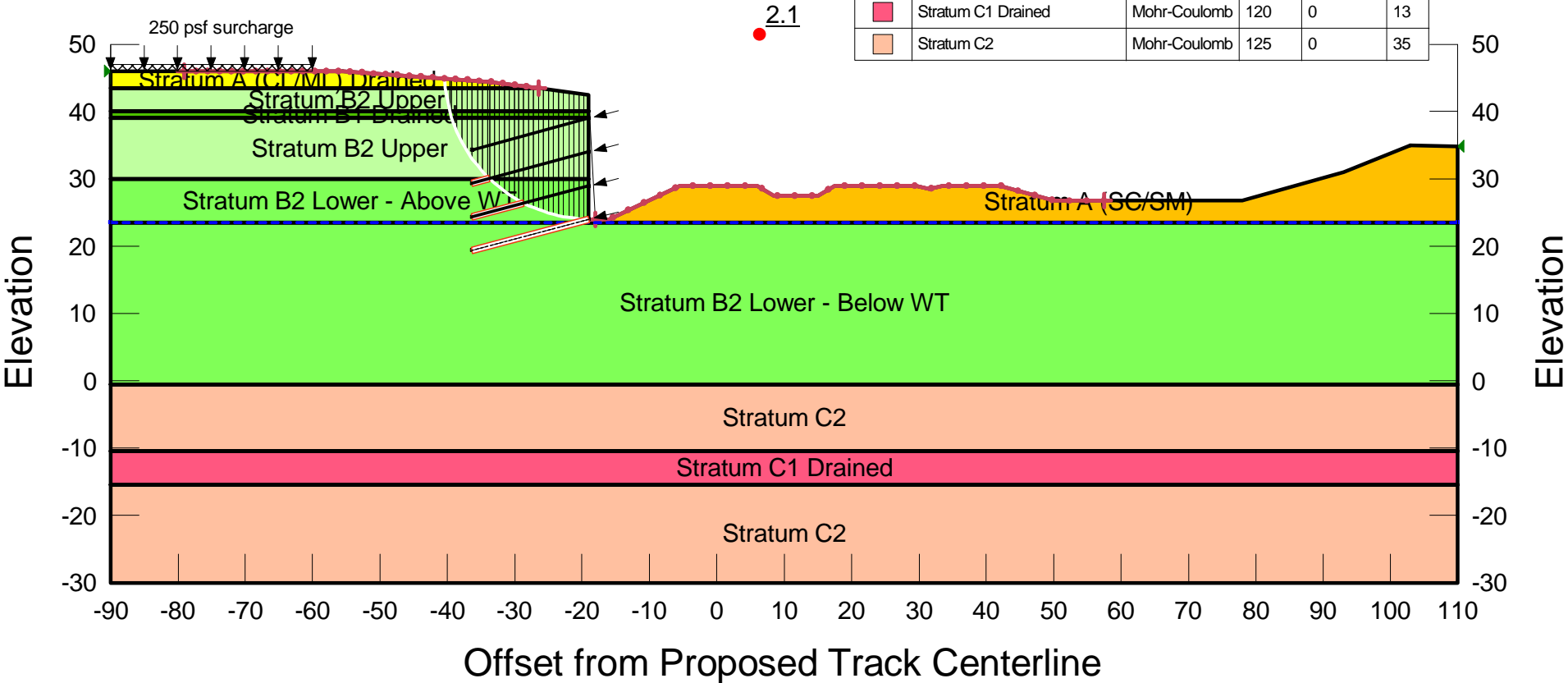
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Stratum A (CL/ML) Undrained	Mohr-Coulomb	120	1,000	0
	Stratum A (SC/SM)	Mohr-Coulomb	120	50	30
	Stratum B1 Undrained	Mohr-Coulomb	120	1,000	0
	Stratum B2 Lower - Above WT	Mohr-Coulomb	125	50	35
	Stratum B2 Lower - Below WT	Mohr-Coulomb	125	0	35
	Stratum B2 Upper	Mohr-Coulomb	120	50	28
	Stratum C1 Undrained	Mohr-Coulomb	120	1,000	0
	Stratum C2	Mohr-Coulomb	125	0	35



Units for Offset and Elevation are in feet.

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8265+50, Long Term
 Section B-B'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Stratum A (CL/ML) Drained	Mohr-Coulomb	120	50	26
	Stratum A (SC/SM)	Mohr-Coulomb	120	50	30
	Stratum B1 Drained	Mohr-Coulomb	120	50	26
	Stratum B2 Lower - Above WT	Mohr-Coulomb	125	50	35
	Stratum B2 Lower - Below WT	Mohr-Coulomb	125	0	35
	Stratum B2 Upper	Mohr-Coulomb	120	50	28
	Stratum C1 Drained	Mohr-Coulomb	120	0	13
	Stratum C2	Mohr-Coulomb	125	0	35



Units for Offset and Elevation are in feet.

8265+50, Short Term

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File Information

File Version: 9.00
Created By: Max Showalter
Last Edited By: Garden, Alistair S
Revision Number: 86
Date: 06/03/2020
Time: 02:43:22 PM
Tool Version: 9.0.3.15488
File Name: SECTION B-B' (BH-01).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 06/04/2020
Last Solved Time: 02:36:53 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8265+50, Short Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001

Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Stratum A (CL/ML) Undrained

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 1,000 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum A (SC/SM)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B2 Upper

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum C2

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-79, 46\) ft](#)
Left-Zone Right Coordinate: [\(-26.5, 43.5\) ft](#)
Left-Zone Increment: [30](#)

Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-18, 24\) ft](#)
Right-Zone Right Coordinate: [\(57.5, 26.76\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-90, 46\) ft](#)
Right Coordinate: [\(110, 34.86538\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-90 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 34\) ft](#)
Inside Point: [\(-36.38666, 29.34126\) ft](#)
Slip Surface Intersection: [\(-35.472168, 29.586297\) ft](#)
Length: [17.999995 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [122.58955 lbf](#)
Pullout Force per Length: [129.48431 lbf/ft](#)

Available Length: 0.94675209 ft
Required Length: 0.94675209 ft
Governing Component: Pullout Resistance

Reinforcement 2

Type: Nail
Outside Point: (-19, 24) ft
Inside Point: (-36.38666, 19.34126) ft
Slip Surface Intersection: (-19.039724, 23.989356) ft
Length: 17.999995 ft
Direction: 15 °
F of S Dependent: Yes
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 2,319.1416 lbf
Pullout Force per Length: 129.48431 lbf/ft
Available Length: 17.95887 ft
Required Length: 17.910599 ft
Governing Component: Tensile Capacity

Reinforcement 3

Type: Nail
Outside Point: (-19, 29) ft
Inside Point: (-36.38666, 24.34126) ft
Slip Surface Intersection: (-29.56457, 26.169233) ft
Length: 17.999995 ft
Direction: 15 °
F of S Dependent: Yes
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1

Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 914.51494 lbf
Pullout Force per Length: 129.48431 lbf/ft
Available Length: 7.0627469 ft
Required Length: 7.0627469 ft
Governing Component: Pullout Resistance

Reinforcement 4

Type: Nail
Outside Point: (-19, 39) ft
Inside Point: (-36.38666, 34.34126) ft
Length: 17.999995 ft
Direction: 15 °
F of S Dependent: Yes
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-90 ft	47 ft
	-60 ft	47 ft

Points

	X	Y
Point 1	-55.5 ft	46 ft
Point 2	-16 ft	24 ft
Point 3	-5.5 ft	29 ft
Point 4	6 ft	29 ft
Point 5	8.5 ft	27.5 ft
Point 6	15 ft	27.5 ft
Point 7	17.5 ft	29 ft
Point 8	29.5 ft	29 ft
Point 9	31.5 ft	28.5 ft
Point 10	33.5 ft	29 ft
Point 11	42 ft	29 ft
Point 12	50 ft	26.76 ft
Point 13	78 ft	26.76 ft
Point 14	93 ft	31 ft
Point 15	103 ft	35 ft
Point 16	-19 ft	23.5 ft
Point 17	-19 ft	40 ft
Point 18	-19 ft	39 ft
Point 19	-19 ft	24 ft
Point 20	-19 ft	42.5 ft
Point 21	-34 ft	44.5 ft
Point 22	-26.5 ft	43.5 ft
Point 23	-19 ft	30 ft
Point 24	-90 ft	-30 ft
Point 25	-90 ft	-15.5 ft
Point 26	-90 ft	-10.5 ft
Point 27	-90 ft	-0.5 ft
Point 28	-90 ft	23.5 ft
Point 29	-90 ft	30 ft
Point 30	-90 ft	39 ft
Point 31	-90 ft	40 ft
Point 32	-90 ft	43.5 ft
Point 33	-90 ft	46 ft
Point 34	110 ft	-30 ft
Point 35	110 ft	-15.5 ft
Point 36	110 ft	-10.5 ft
Point 37	110 ft	-0.5 ft
Point 38	110 ft	23.5 ft
Point 39	110 ft	34.86538 ft

Regions

	Material	Points	Area
Region 1	Stratum A (CL/ML) Undrained	1,33,32,22,21	127.63 ft²
Region 2	Stratum A (SC/SM)	15,14,13,12,11,10,9,8,7,6,5,4,3,2,19,16,38,39	661.8 ft²
Region 3	Stratum B2 Upper	18,30,29,23	639 ft²
Region 4	Stratum B2 Lower - Above WT	19,23,29,28,16	461.5 ft²
Region 5	Stratum B1 Undrained	18,17,31,30	71 ft²
Region 6	Stratum B2 Upper	17,20,22,32,31	244.75 ft²
Region 7	Stratum C2	25,24,34,35	2,900 ft²
Region 8	Stratum C1 Undrained	26,25,35,36	1,000 ft²
Region 9	Stratum C2	27,26,36,37	2,000 ft²
Region 10	Stratum B2 Lower - Below WT	16,28,27,37,38	4,800 ft²

Current Slip Surface

Slip Surface: 2,949
Factor of Safety: 2.3
Volume: 390.51926 ft³
Weight: 47,209.513 lbf
Resisting Moment: 1,202,153.8 lbf-ft
Activating Moment: 529,362.16 lbf-ft
Resisting Force: 37,783.976 lbf
Activating Force: 16,640.042 lbf
Slip Rank: 1 of 4,805 slip surfaces
Exit: (-18, 24) ft
Entry: (-45.698689, 45.316188) ft
Radius: 27.60149 ft
Center: (-18.819515, 51.589321) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-45.453847 ft	44.408094 ft	-1,304.6651 psf	-1,447.9104 psf	-0 psf	1,000 psf
Slice 2	-44.539532 ft	41.75 ft	-1,138.8 psf	253.71999 psf	134.90531 psf	50 psf
Slice 3	-43.626392 ft	39.5 ft	-998.4 psf	-124.10914 psf	-0 psf	1,000 psf
Slice 4	-42.922348 ft	38.172925 ft	-915.59052 psf	552.03013 psf	293.51962 psf	50 psf
Slice 5	-42.001596 ft	36.632307 ft	-819.45596 psf	676.9197 psf	359.92459 psf	50 psf
				787.88281 psf	418.92472 psf	50 psf

Slice 6	-41.080844 ft	35.289991 ft	-735.69543 psf			
Slice 7	-40.160092 ft	34.099481 ft	-661.4076 psf	889.51224 psf	472.96205 psf	50 psf
Slice 8	-39.23934 ft	33.031184 ft	-594.74591 psf	984.9858 psf	523.72624 psf	50 psf
Slice 9	-38.318588 ft	32.064848 ft	-534.44652 psf	1,076.5969 psf	572.43674 psf	50 psf
Slice 10	-37.397836 ft	31.185876 ft	-479.59869 psf	1,166.0337 psf	619.99109 psf	50 psf
Slice 11	-36.477084 ft	30.383341 ft	-429.52048 psf	1,254.5351 psf	667.04817 psf	50 psf
Slice 12	-35.512531 ft	29.616963 ft	-381.69847 psf	1,311.0356 psf	917.99702 psf	50 psf
Slice 13	-34.504177 ft	28.885619 ft	-336.06261 psf	1,414.6263 psf	990.53198 psf	50 psf
Slice 14	-33.53125 ft	28.241942 ft	-295.89717 psf	1,512.5534 psf	1,059.1013 psf	50 psf
Slice 15	-32.59375 ft	27.676562 ft	-260.61746 psf	1,603.9006 psf	1,123.0633 psf	50 psf
Slice 16	-31.65625 ft	27.160239 ft	-228.39888 psf	1,694.9822 psf	1,186.8393 psf	50 psf
Slice 17	-30.71875 ft	26.689913 ft	-199.05055 psf	1,785.1688 psf	1,249.9887 psf	50 psf
Slice 18	-29.78125 ft	26.263016 ft	-172.41221 psf	1,907.3409 psf	1,335.5344 psf	50 psf
Slice 19	-28.84375 ft	25.877382 ft	-148.34862 psf	1,992.4718 psf	1,395.1438 psf	50 psf
Slice 20	-27.90625 ft	25.531174 ft	-126.74524 psf	2,072.8951 psf	1,451.4568 psf	50 psf
Slice 21	-26.96875 ft	25.222837 ft	-107.50502 psf	2,147.1995 psf	1,503.4853 psf	50 psf
Slice 22	-26.03125 ft	24.951054 ft	-90.545753 psf	2,213.9174 psf	1,550.2017 psf	50 psf
Slice 23	-25.09375 ft	24.714714 ft	-75.798145 psf	2,271.6005 psf	1,590.5918 psf	50 psf
Slice 24	-24.15625 ft	24.512888 ft	-63.2042 psf	2,318.9041 psf	1,623.7141 psf	50 psf
Slice 25	-23.21875 ft	24.344808 ft	-52.715992 psf	2,354.6737 psf	1,648.7603 psf	50 psf
Slice 26	-22.28125 ft	24.209851 ft	-44.29469 psf	2,378.0274 psf	1,665.1127 psf	50 psf
Slice 27	-21.34375 ft	24.107529 ft	-37.909806 psf	2,388.4256 psf	1,672.3936 psf	50 psf
Slice 28	-20.40625 ft	24.037478 ft	-33.538625 psf	2,385.721 psf	1,670.4998 psf	50 psf
Slice 29	-19.46875 ft	23.999452 ft	-31.165791 psf	3,075.9685 psf	2,153.8163 psf	50 psf

Slice 30	-18.5 ft	23.994211 ft	-30.838745 psf	1.5675677 psf	0.90503561 psf	50 psf
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8265+50, Long Term

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File Information

File Version: 9.00
Created By: [Max Showalter](#)
Last Edited By: [Garden, Alistair S](#)
Revision Number: 82
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Tool Version: 9.0.3.15488
File Name: [SECTION B-B' \(BH-01\).gsz](#)
Directory: [C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\](#)
Last Solved Date: 05/28/2020
Last Solved Time: 02:57:00 PM

Project Settings

Unit System: [U.S. Customary Units](#)

Analysis Settings

8265+50, Long Term

Kind: [SLOPE/W](#)
Method: [Morgenstern-Price](#)
Settings
 Side Function
 Interslice force function option: [Half-Sine](#)
 PWP Conditions from: [Piezometric Line](#)
 Apply Phreatic Correction: [No](#)
 Use Staged Rapid Drawdown: [No](#)
 Unit Weight of Water: [62.4 pcf](#)
Slip Surface
 Direction of movement: [Left to Right](#)
 Use Passive Mode: [No](#)
 Slip Surface Option: [Entry and Exit](#)
 Critical slip surfaces saved: [1](#)
 Optimize Critical Slip Surface Location: [No](#)
 Tension Crack Option: [\(none\)](#)
Distribution
 F of S Calculation Option: [Constant](#)
Advanced
 Geometry Settings
 Minimum Slip Surface Depth: [0.1 ft](#)
 Number of Slices: [30](#)

Factor of Safety Convergence Settings
 Maximum Number of Iterations: [100](#)
 Tolerable difference in F of S: [0.001](#)
Solution Settings
 Search Method: [Linear Search](#)
 Must Obtain at Lambda Factor of Safety: [0.2](#)
 Lambda
 Lambda 1: [-1](#)
 Lambda 2: [-0.8](#)
 Lambda 3: [-0.6](#)
 Lambda 4: [-0.4](#)
 Lambda 5: [-0.2](#)
 Lambda 6: [0](#)
 Lambda 7: [0.2](#)
 Lambda 8: [0.4](#)
 Lambda 9: [0.6](#)
 Lambda 10: [0.8](#)
 Lambda 11: [1](#)

Materials

Stratum A (SC/SM)

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [30 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
 Piezometric Line: [1](#)

Stratum B1 Drained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [26 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
 Piezometric Line: [1](#)

Stratum B2 Upper

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [28 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
 Piezometric Line: [1](#)

Stratum C1 Drained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi': [13 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C2

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum A (CL/ML) Drained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [26 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-79, 46\) ft](#)
Left-Zone Right Coordinate: [\(-26.5, 43.5\) ft](#)
Left-Zone Increment: [30](#)

Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-18, 24\) ft](#)
Right-Zone Right Coordinate: [\(57.5, 26.76\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-90, 46\) ft](#)
Right Coordinate: [\(110, 34.86538\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-90 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 34\) ft](#)
Inside Point: [\(-36.38666, 29.34126\) ft](#)
Slip Surface Intersection: [\(-33.76384, 30.044042\) ft](#)
Length: [17.999995 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [377.83726 lbf](#)
Pullout Force per Length: [139.14897 lbf/ft](#)

Available Length: 2.7153434 ft
Required Length: 2.7153434 ft
Governing Component: Pullout Resistance

Reinforcement 2

Type: Nail
Outside Point: (-19, 24) ft
Inside Point: (-36.38666, 19.34126) ft
Slip Surface Intersection: (-19.030974, 23.991701) ft
Length: 17.999995 ft
Direction: 15 °
F of S Dependent: Yes
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 2,492.2415 lbf
Pullout Force per Length: 139.14897 lbf/ft
Available Length: 17.967928 ft
Required Length: 17.910599 ft
Governing Component: Tensile Capacity

Reinforcement 3

Type: Nail
Outside Point: (-19, 29) ft
Inside Point: (-36.38666, 24.34126) ft
Slip Surface Intersection: (-28.673488, 26.407998) ft
Length: 17.999995 ft
Direction: 15 °
F of S Dependent: Yes
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1

Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 1,111.1412 lbf
Pullout Force per Length: 139.14897 lbf/ft
Available Length: 7.985263 ft
Required Length: 7.985263 ft
Governing Component: Pullout Resistance

Reinforcement 4

Type: Nail
Outside Point: (-19, 39) ft
Inside Point: (-36.38666, 34.34126) ft
Length: 17.999995 ft
Direction: 15 °
F of S Dependent: Yes
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-90 ft	47 ft
	-60 ft	47 ft

Points

	X	Y
Point 1	-55.5 ft	46 ft
Point 2	-16 ft	24 ft
Point 3	-5.5 ft	29 ft
Point 4	6 ft	29 ft
Point 5	8.5 ft	27.5 ft
Point 6	15 ft	27.5 ft
Point 7	17.5 ft	29 ft
Point 8	29.5 ft	29 ft
Point 9	31.5 ft	28.5 ft
Point 10	33.5 ft	29 ft
Point 11	42 ft	29 ft
Point 12	50 ft	26.76 ft
Point 13	78 ft	26.76 ft
Point 14	93 ft	31 ft
Point 15	103 ft	35 ft
Point 16	-19 ft	23.5 ft
Point 17	-19 ft	40 ft
Point 18	-19 ft	39 ft
Point 19	-19 ft	24 ft
Point 20	-19 ft	42.5 ft
Point 21	-34 ft	44.5 ft
Point 22	-26.5 ft	43.5 ft
Point 23	-19 ft	30 ft
Point 24	-90 ft	-30 ft
Point 25	-90 ft	-15.5 ft
Point 26	-90 ft	-10.5 ft
Point 27	-90 ft	-0.5 ft
Point 28	-90 ft	23.5 ft
Point 29	-90 ft	30 ft
Point 30	-90 ft	39 ft
Point 31	-90 ft	40 ft
Point 32	-90 ft	43.5 ft
Point 33	-90 ft	46 ft
Point 34	110 ft	-30 ft
Point 35	110 ft	-15.5 ft
Point 36	110 ft	-10.5 ft
Point 37	110 ft	-0.5 ft
Point 38	110 ft	23.5 ft
Point 39	110 ft	34.86538 ft

Regions

	Material	Points	Area
Region 1	Stratum A (CL/ML) Drained	1,33,32,22,21	127.63 ft²
Region 2	Stratum A (SC/SM)	15,14,13,12,11,10,9,8,7,6,5,4,3,2,19,16,38,39	661.8 ft²
Region 3	Stratum B2 Upper	18,30,29,23	639 ft²
Region 4	Stratum B2 Lower - Above WT	19,23,29,28,16	461.5 ft²
Region 5	Stratum B1 Drained	18,17,31,30	71 ft²
Region 6	Stratum B2 Upper	17,20,22,32,31	244.75 ft²
Region 7	Stratum C2	25,24,34,35	2,900 ft²
Region 8	Stratum C1 Drained	26,25,35,36	1,000 ft²
Region 9	Stratum C2	27,26,36,37	2,000 ft²
Region 10	Stratum B2 Lower - Below WT	16,28,27,37,38	4,800 ft²

Current Slip Surface

Slip Surface: 3,415
Factor of Safety: 2.1
Volume: 324.75433 ft³
Weight: 39,271.677 lbf
Resisting Moment: 785,336.77 lbf-ft
Activating Moment: 371,632.06 lbf-ft
Resisting Force: 33,176.326 lbf
Activating Force: 15,698.489 lbf
Slip Rank: 1 of 4,805 slip surfaces
Exit: (-18, 24) ft
Entry: (-40.449585, 44.949971) ft
Radius: 21.762923 ft
Center: (-18.701432, 45.751616) ft

Slip Slices

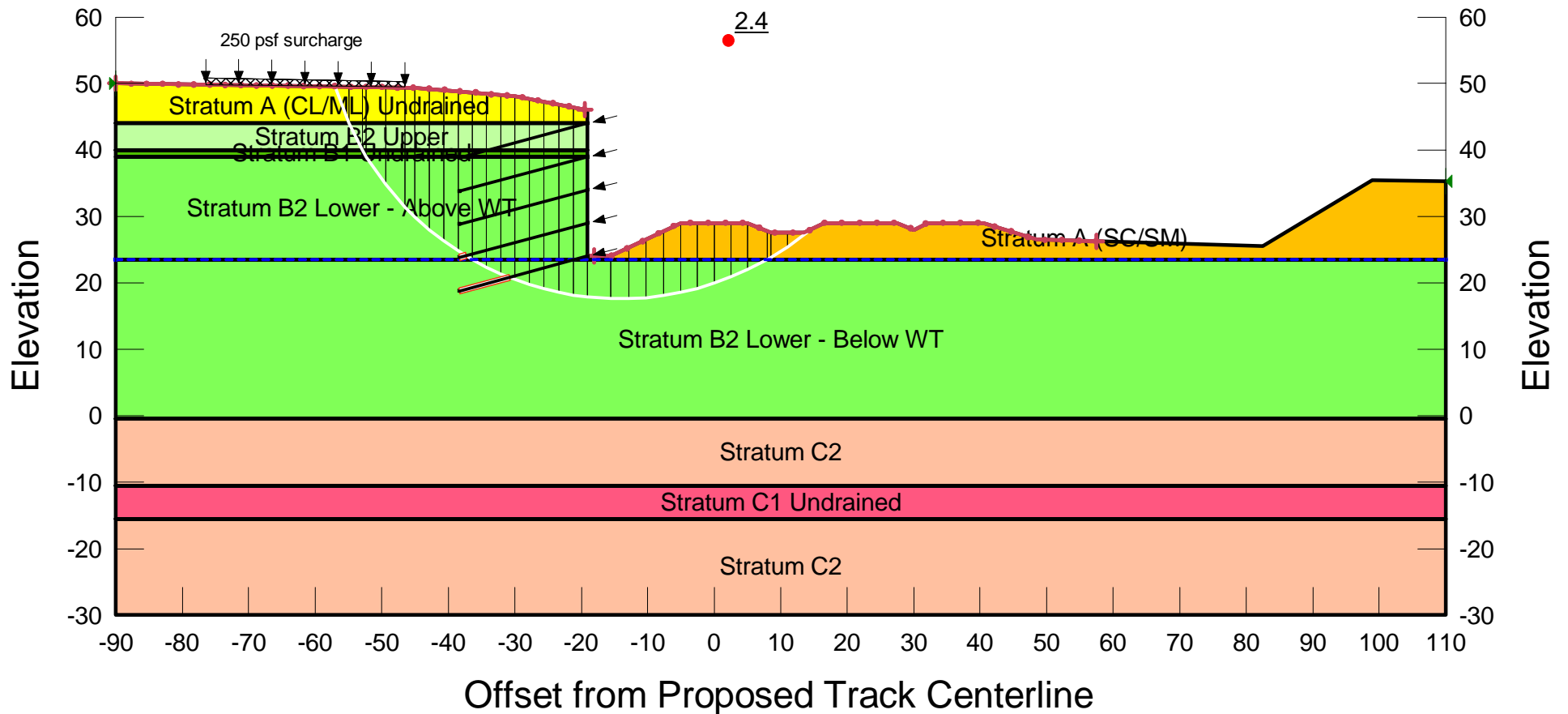
	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-40.398575 ft	44.224986 ft	-1,293.2391 psf	-56.490243 psf	-27.552132 psf	50 psf
Slice 2	-40.019065 ft	41.75 ft	-1,138.8 psf	97.586049 psf	51.887423 psf	50 psf
Slice 3	-39.540568 ft	39.5 ft	-998.4 psf	263.78952 psf	128.65874 psf	50 psf
Slice 4	-39.005531 ft	37.992432 ft	-904.32775 psf	349.70187 psf	185.93978 psf	50 psf
Slice 5	-38.235449 ft	36.197613 ft	-792.33107 psf	457.87821 psf	243.45816 psf	50 psf
				542.67515 psf	288.5455 psf	50 psf

Slice 6	-37.465367 ft	34.753446 ft	-702.21504 psf			
Slice 7	-36.695286 ft	33.529651 ft	-625.85023 psf	617.36407 psf	328.2583 psf	50 psf
Slice 8	-35.925204 ft	32.463684 ft	-559.33389 psf	688.69788 psf	366.18716 psf	50 psf
Slice 9	-35.155122 ft	31.519453 ft	-500.41386 psf	760.81714 psf	404.53365 psf	50 psf
Slice 10	-34.385041 ft	30.673799 ft	-447.64509 psf	836.59739 psf	444.82672 psf	50 psf
Slice 11	-33.859234 ft	30.136644 ft	-414.1266 psf	922.06878 psf	490.27267 psf	50 psf
Slice 12	-33.357545 ft	29.671048 ft	-385.0734 psf	943.01863 psf	660.30875 psf	50 psf
Slice 13	-32.635699 ft	29.041135 ft	-345.76682 psf	1,034.1267 psf	724.10334 psf	50 psf
Slice 14	-31.913852 ft	28.464326 ft	-309.77391 psf	1,132.8755 psf	793.24796 psf	50 psf
Slice 15	-31.192005 ft	27.935441 ft	-276.7715 psf	1,239.99 psf	868.25037 psf	50 psf
Slice 16	-30.470158 ft	27.450311 ft	-246.49941 psf	1,355.8743 psf	949.39343 psf	50 psf
Slice 17	-29.748311 ft	27.005529 ft	-218.74503 psf	1,480.5407 psf	1,036.6858 psf	50 psf
Slice 18	-29.026464 ft	26.598277 ft	-193.33249 psf	1,689.4755 psf	1,182.9835 psf	50 psf
Slice 19	-28.304617 ft	26.2262 ft	-170.1149 psf	1,831.2695 psf	1,282.2687 psf	50 psf
Slice 20	-27.58277 ft	25.887318 ft	-148.96866 psf	1,976.8704 psf	1,384.2196 psf	50 psf
Slice 21	-26.860923 ft	25.579955 ft	-129.78917 psf	2,123.4891 psf	1,486.8831 psf	50 psf
Slice 22	-26.125 ft	25.297856 ft	-112.18623 psf	2,266.4851 psf	1,587.0099 psf	50 psf
Slice 23	-25.375 ft	25.040917 ft	-96.153201 psf	2,408.7095 psf	1,686.5966 psf	50 psf
Slice 24	-24.625 ft	24.813988 ft	-81.992854 psf	2,537.8713 psf	1,777.0366 psf	50 psf
Slice 25	-23.875 ft	24.616102 ft	-69.644774 psf	2,648.0349 psf	1,854.174 psf	50 psf
Slice 26	-23.125 ft	24.446449 ft	-59.058387 psf	2,733.3994 psf	1,913.9469 psf	50 psf
Slice 27	-22.375 ft	24.304356 ft	-50.19183 psf	2,788.9018 psf	1,952.81 psf	50 psf
Slice 28	-21.625 ft	24.18928 ft	-43.011058 psf	2,810.8432 psf	1,968.1736 psf	50 psf
Slice 29	-20.875 ft	24.100788 ft	-37.489156 psf	2,797.4257 psf	1,958.7786 psf	50 psf

Slice 30	-20.125 ft	24.038555 ft	-33.605816 psf	2,749.0795 psf	1,924.9262 psf	50 psf
Slice 31	-19.375 ft	24.002355 ft	-31.346956 psf	3,853.2597 psf	2,698.0815 psf	50 psf
Slice 32	-18.5 ft	23.995371 ft	-30.911133 psf	3,101.7989 psf	1,790.8244 psf	50 psf

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8266+00, Short Term
 Section C-C'

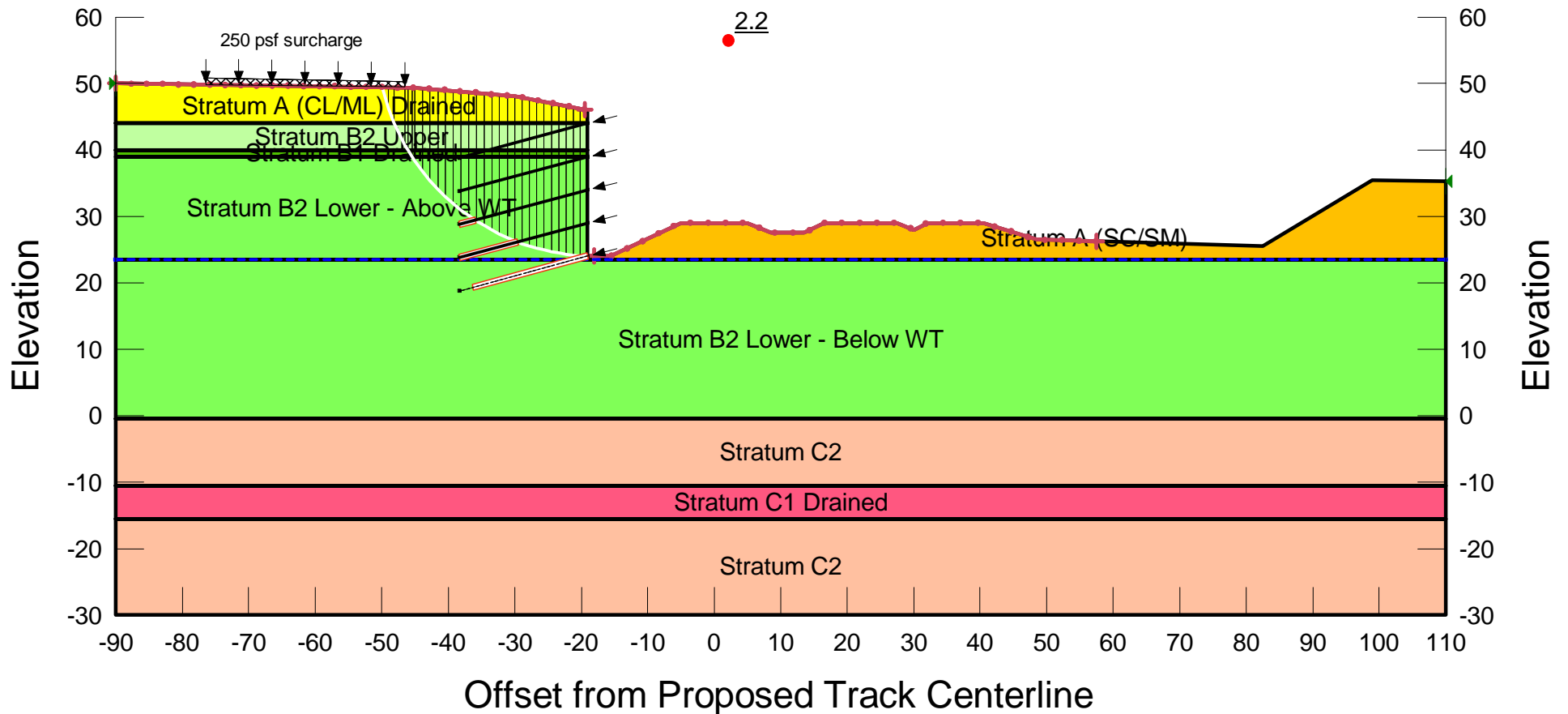
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Yellow	Stratum A (CL/ML) Undrained	Mohr-Coulomb	120	1,000	0
Orange	Stratum A (SC/SM)	Mohr-Coulomb	120	50	30
Dark Green	Stratum B1 Undrained	Mohr-Coulomb	125	1,000	0
Light Green	Stratum B2 Lower - Above WT	Mohr-Coulomb	125	50	35
Light Green	Stratum B2 Lower - Below WT	Mohr-Coulomb	125	0	35
Light Green	Stratum B2 Upper	Mohr-Coulomb	120	50	28
Pink	Stratum C1 Undrained	Mohr-Coulomb	120	1,000	0
Light Orange	Stratum C2	Mohr-Coulomb	125	0	35



Units for Offset and Elevation are in feet.

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8266+00, Long Term
 Section C-C'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Stratum A (CL/ML) Drained	Mohr-Coulomb	120	50	26
	Stratum A (SC/SM)	Mohr-Coulomb	120	50	30
	Stratum B1 Drained	Mohr-Coulomb	120	50	26
	Stratum B2 Lower - Above WT	Mohr-Coulomb	125	50	35
	Stratum B2 Lower - Below WT	Mohr-Coulomb	125	0	35
	Stratum B2 Upper	Mohr-Coulomb	120	50	28
	Stratum C1 Drained	Mohr-Coulomb	120	0	13
	Stratum C2	Mohr-Coulomb	125	0	35



Units for Offset and Elevation are in feet.

8266+00, Short Term

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File Information

File Version: 9.00
Created By: [Max Showalter](#)
Last Edited By: [Garden, Alistair S](#)
Revision Number: 57
Date: 06/04/2020
Time: 02:33:39 PM
Tool Version: 9.0.3.15488
File Name: [SECTION C-C' \(BH-02\).gsz](#)
Directory: [C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\](#)
Last Solved Date: 06/04/2020
Last Solved Time: 02:33:49 PM

Project Settings

Unit System: [U.S. Customary Units](#)

Analysis Settings

8266+00, Short Term

Kind: [SLOPE/W](#)
Method: [Morgenstern-Price](#)
Settings
Side Function
Interslice force function option: [Half-Sine](#)
PWP Conditions from: [Piezometric Line](#)
Apply Phreatic Correction: [No](#)
Use Staged Rapid Drawdown: [No](#)
Unit Weight of Water: [62.4 pcf](#)
Slip Surface
Direction of movement: [Left to Right](#)
Use Passive Mode: [No](#)
Slip Surface Option: [Entry and Exit](#)
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: [No](#)
Tension Crack Option: [\(none\)](#)
Distribution
F of S Calculation Option: [Constant](#)
Advanced
Geometry Settings
Minimum Slip Surface Depth: [0.1 ft](#)
Number of Slices: [30](#)

Factor of Safety Convergence Settings
Maximum Number of Iterations: [100](#)
Tolerable difference in F of S: [0.001](#)
Solution Settings
Search Method: [Linear Search](#)
Must Obtain at Lambda Factor of Safety: [0.2](#)
Lambda
Lambda 1: [-1](#)
Lambda 2: [-0.8](#)
Lambda 3: [-0.6](#)
Lambda 4: [-0.4](#)
Lambda 5: [-0.2](#)
Lambda 6: [0](#)
Lambda 7: [0.2](#)
Lambda 8: [0.4](#)
Lambda 9: [0.6](#)
Lambda 10: [0.8](#)
Lambda 11: [1](#)

Materials

Stratum A (CL/ML) Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum A (SC/SM)

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [30 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Upper

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [28 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C2

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-90, 50\) ft](#)
Left-Zone Right Coordinate: [\(-19.53268, 46.1029\) ft](#)
Left-Zone Increment: [30](#)

Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-18, 24\) ft](#)
Right-Zone Right Coordinate: [\(57.5, 26.23421\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-90, 50\) ft](#)
Right Coordinate: [\(110, 35.30357\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-90 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 29\) ft](#)
Inside Point: [\(-38.31852, 23.82362\) ft](#)
Slip Surface Intersection: [\(-37.307733, 24.094459\) ft](#)
Length: [20.000003 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [127.87795 lbf](#)
Pullout Force per Length: [122.20242 lbf/ft](#)

Available Length: 1.0464437 ft
 Required Length: 1.0464437 ft
 Governing Component: Pullout Resistance

Reinforcement 2

Type: Nail
 Outside Point: (-19, 44) ft
 Inside Point: (-38.31852, 38.82362) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 3

Type: Nail
 Outside Point: (-19, 34) ft
 Inside Point: (-38.31852, 28.82362) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft

Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 4

Type: Nail
 Outside Point: (-19, 24) ft
 Inside Point: (-38.31852, 18.82362) ft
 Slip Surface Intersection: (-30.790608, 20.840717) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 2,291.6932 lbf
 Pullout Force per Length: 294.05307 lbf/ft
 Available Length: 7.7934681 ft
 Required Length: 7.7934681 ft
 Governing Component: Pullout Resistance

Reinforcement 5

Type: Nail
 Outside Point: (-19, 39) ft
 Inside Point: (-38.31852, 33.82362) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 1
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf

Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 588.10614 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1
Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-76.5 ft	50.85 ft
	-46.5 ft	50.35 ft

Points

	X	Y
Point 1	-90 ft	50 ft
Point 2	-45 ft	49.375 ft
Point 3	-30 ft	48.125 ft
Point 4	-19 ft	46 ft
Point 5	-19 ft	24 ft
Point 6	-15.5 ft	24 ft
Point 7	-5 ft	29 ft
Point 8	5 ft	29 ft
Point 9	8.5 ft	27.5 ft
Point 10	13.5 ft	27.5 ft
Point 11	16.5 ft	29 ft
Point 12	27.5 ft	29 ft
Point 13	30 ft	28 ft
Point 14	32 ft	29 ft
Point 15	40.5 ft	29 ft
Point 16	48.45 ft	26.5 ft
Point 17	82.5 ft	25.5 ft
Point 18	99 ft	35.5 ft

Point 19	-90 ft	44 ft
Point 20	-19 ft	44 ft
Point 21	-90 ft	40 ft
Point 22	-19 ft	40 ft
Point 23	-90 ft	39 ft
Point 24	-19 ft	39 ft
Point 25	-90 ft	-0.5 ft
Point 26	-90 ft	-10.5 ft
Point 27	-90 ft	-15.5 ft
Point 28	-90 ft	-30 ft
Point 29	-90 ft	23.5 ft
Point 30	110 ft	-30 ft
Point 31	110 ft	-15.5 ft
Point 32	110 ft	-10.5 ft
Point 33	110 ft	-0.5 ft
Point 34	110 ft	23.5 ft
Point 35	110 ft	35.30357 ft
Point 36	-19 ft	23.5 ft

Regions

	Material	Points	Area
Region 1	Stratum A (CL/ML) Undrained	1,2,3,4,20,19	360.88 ft²
Region 2	Stratum B2 Upper	19,20,22,21	284 ft²
Region 3	Stratum B1 Undrained	21,22,24,23	71 ft²
	Stratum A (SC/SM)	35,18,17,16,15,14,13,12,11,10,9,8,7,6,5,36,34	634.21 ft²

Region 4			
Region 5	Stratum B2 Lower - Below WT	25,33,34,36,29	4,800 ft ²
Region 6	Stratum C2	25,33,32,26	2,000 ft ²
Region 7	Stratum C1 Undrained	26,32,31,27	1,000 ft ²
Region 8	Stratum C2	27,31,30,28	2,900 ft ²
Region 9	Stratum B2 Lower - Above WT	24,23,29,36,5	1,100.5 ft ²

Current Slip Surface

Slip Surface: 2,239

Factor of Safety: 2.4

Volume: 1,041.0156 ft³

Weight: 128,029.71 lbf

Resisting Moment: 4,225,642.1 lbf-ft

Activating Moment: 1,756,168.3 lbf-ft

Resisting Force: 78,723.214 lbf

Activating Force: 32,757.777 lbf

Slip Rank: 1 of 4,805 slip surfaces

Exit: (14.313246, 27.906623) ft

Entry: (-57.001831, 49.541692) ft

Radius: 44.668457 ft

Center: (-14.193099, 62.296437) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-55.972152 ft	46.770846 ft	-1,452.1008 psf	-504.79203 psf	-0 psf	1,000 psf
Slice 2	-53.920693 ft	42 ft	-1,154.4 psf	757.9422 psf	403.00501 psf	50 psf
Slice 3	-52.602154 ft	39.5 ft	-998.4 psf	715.07864 psf	0 psf	1,000 psf
Slice 4	-50.854046 ft	36.904536 ft	-836.44304 psf	1,153.3751 psf	807.60191 psf	50 psf
Slice 5	-47.951349 ft	33.129272 ft	-600.86658 psf	1,524.142 psf	1,067.2157 psf	50 psf
Slice 6	-45.75 ft	30.700402 ft	-449.30505 psf	1,605.7059 psf	1,124.3274 psf	50 psf
Slice 7	-43.916434 ft	28.984494 ft	-342.23243 psf	1,788.5791 psf	1,252.3765 psf	50 psf
Slice 8	-41.749302 ft	27.167672 ft	-228.86271 psf	1,989.1955 psf	1,392.8497 psf	50 psf

Slice 9	-39.58217 ft	25.568641 ft	-129.08322 psf	2,179.7487 psf	1,526.2765 psf	50 psf
Slice 10	-37.415037 ft	24.159799 ft	-41.171439 psf	2,365.0992 psf	1,656.0603 psf	50 psf
Slice 11	-35.276226 ft	22.934783 ft	35.269529 psf	2,549.0824 psf	1,760.1908 psf	0 psf
Slice 12	-33.165736 ft	21.874274 ft	101.4453 psf	2,719.403 psf	1,833.1137 psf	0 psf
Slice 13	-31.055245 ft	20.94864 ft	159.20488 psf	2,957.1396 psf	1,959.135 psf	0 psf
Slice 14	-28.9 ft	20.134595 ft	210.00124 psf	3,105.4444 psf	2,027.4112 psf	0 psf
Slice 15	-26.7 ft	19.429953 ft	253.97095 psf	3,238.6814 psf	2,089.9167 psf	0 psf
Slice 16	-24.5 ft	18.848068 ft	290.28054 psf	3,361.8369 psf	2,150.727 psf	0 psf
Slice 17	-22.3 ft	18.384047 ft	319.23544 psf	3,473.3569 psf	2,208.5396 psf	0 psf
Slice 18	-20.1 ft	18.034173 ft	341.0676 psf	3,571.1587 psf	2,261.7342 psf	0 psf
Slice 19	-17.25 ft	17.767239 ft	357.72428 psf	3,615.00803 psf	230.19353 psf	0 psf
Slice 20	-14.1875 ft	17.647267 ft	365.21051 psf	955.23288 psf	413.13811 psf	0 psf
Slice 21	-11.5625 ft	17.724895 ft	360.36653 psf	1,148.862 psf	552.11045 psf	0 psf
Slice 22	-8.9375 ft	17.957934 ft	345.82492 psf	1,325.9629 psf	686.30003 psf	0 psf
Slice 23	-6.3125 ft	18.348864 ft	321.43086 psf	1,481.9536 psf	812.6068 psf	0 psf
Slice 24	-3.75 ft	18.88492 ft	287.98098 psf	1,525.0643 psf	866.21504 psf	0 psf
Slice 25	-1.25 ft	19.564232 ft	245.59194 psf	1,448.2259 psf	842.09336 psf	0 psf
Slice 26	1.25 ft	20.403635 ft	193.21319 psf	1,336.9641 psf	800.86297 psf	0 psf
Slice 27	3.75 ft	21.413033 ft	130.22676 psf	1,190.5519 psf	742.44766 psf	0 psf
Slice 28	6.4726362 ft	22.730819 ft	47.996878 psf	894.77918 psf	592.92335 psf	0 psf
Slice 29	8.2226362 ft	23.660922 ft	-10.041547 psf	625.08662 psf	360.89393 psf	50 psf
Slice 30	9.75 ft	24.616129 ft	-69.646429 psf	460.64292 psf	265.95231 psf	50 psf
Slice 31	12.25 ft	26.329418 ft	-176.55568 psf	198.63721 psf	114.68325 psf	50 psf
Slice 32	13.906623 ft	27.577523 ft	-254.43744 psf	40.264063 psf	23.246468 psf	50 psf

8266+00, Long Term

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File Information

File Version: 9.00
Created By: Max Showalter
Last Edited By: Garden, Alistair S
Revision Number: 54
Date: 05/28/2020
Time: 02:59:31 PM
Tool Version: 9.0.3.15488
File Name: SECTION C-C' (BH-02).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 05/28/2020
Last Solved Time: 02:59:48 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8266+00, Long Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Stratum A (SC/SM)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B2 Upper

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum C2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum A (CL/ML) Drained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [26 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Drained
Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [26 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Drained
Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi': [13 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Above WT
Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 Lower - Below WT
Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-90, 50\) ft](#)
Left-Zone Right Coordinate: [\(-19.53268, 46.1029\) ft](#)
Left-Zone Increment: [30](#)

Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-18, 24\) ft](#)
Right-Zone Right Coordinate: [\(57.5, 26.23421\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-90, 50\) ft](#)
Right Coordinate: [\(110, 35.30357\) ft](#)

Piezometric Lines

Piezometric Line [1](#)

Coordinates

	X	Y
Coordinate 1	-90 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement [1](#)
Type: [Nail](#)
Outside Point: [\(-19, 29\) ft](#)
Inside Point: [\(-38.31852, 23.82362\) ft](#)
Slip Surface Intersection: [\(-29.555508, 26.171661\) ft](#)
Length: [20.000003 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [1,199.6694 lbf](#)
Pullout Force per Length: [132.23669 lbf/ft](#)

Available Length: 9.0721372 ft
 Required Length: 9.0721372 ft
 Governing Component: Pullout Resistance

Reinforcement 2

Type: Nail
 Outside Point: (-19, 44) ft
 Inside Point: (-38.31852, 38.82362) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 3

Type: Nail
 Outside Point: (-19, 34) ft
 Inside Point: (-38.31852, 28.82362) ft
 Slip Surface Intersection: (-35.948604, 29.458637) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip

Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 721.46446 lbf
 Pullout Force per Length: 294.05307 lbf/ft
 Available Length: 2.4535178 ft
 Required Length: 2.4535178 ft
 Governing Component: Pullout Resistance

Reinforcement 4

Type: Nail
 Outside Point: (-19, 24) ft
 Inside Point: (-38.31852, 18.82362) ft
 Slip Surface Intersection: (-19.022486, 23.993975) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 5,266.6667 lbf
 Pullout Force per Length: 294.05307 lbf/ft
 Available Length: 19.976724 ft
 Required Length: 17.910599 ft
 Governing Component: Tensile Capacity

Reinforcement 5

Type: Nail
 Outside Point: (-19, 39) ft
 Inside Point: (-38.31852, 33.82362) ft
 Length: 20.000003 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 1
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft

Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 588.10614 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1
Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-76.5 ft	50.85 ft
	-46.5 ft	50.35 ft

Points

	X	Y
Point 1	-90 ft	50 ft
Point 2	-45 ft	49.375 ft
Point 3	-30 ft	48.125 ft
Point 4	-19 ft	46 ft
Point 5	-19 ft	24 ft
Point 6	-15.5 ft	24 ft
Point 7	-5 ft	29 ft
Point 8	5 ft	29 ft
Point 9	8.5 ft	27.5 ft
Point 10	13.5 ft	27.5 ft
Point 11	16.5 ft	29 ft
Point 12	27.5 ft	29 ft
Point 13	30 ft	28 ft
Point 14	32 ft	29 ft
Point 15	40.5 ft	29 ft
Point 16	48.45 ft	26.5 ft
Point 17	82.5 ft	25.5 ft

Point 18	99 ft	35.5 ft
Point 19	-90 ft	44 ft
Point 20	-19 ft	44 ft
Point 21	-90 ft	40 ft
Point 22	-19 ft	40 ft
Point 23	-90 ft	39 ft
Point 24	-19 ft	39 ft
Point 25	-90 ft	-0.5 ft
Point 26	-90 ft	-10.5 ft
Point 27	-90 ft	-15.5 ft
Point 28	-90 ft	-30 ft
Point 29	-90 ft	23.5 ft
Point 30	110 ft	-30 ft
Point 31	110 ft	-15.5 ft
Point 32	110 ft	-10.5 ft
Point 33	110 ft	-0.5 ft
Point 34	110 ft	23.5 ft
Point 35	110 ft	35.30357 ft
Point 36	-19 ft	23.5 ft

Regions

	Material	Points	Area
Region 1	Stratum A (CL/ML) Drained	1,2,3,4,20,19	360.88 ft²
Region 2	Stratum B2 Upper	19,20,22,21	284 ft²
	Stratum B1 Drained	21,22,24,23	71 ft²

Region 3			
Region 4	Stratum A (SC/SM)	35,18,17,16,15,14,13,12,11,10,9,8,7,6,5,36,34	634.21 ft ²
Region 5	Stratum B2 Lower - Below WT	25,33,34,36,29	4,800 ft ²
Region 6	Stratum C2	25,33,32,26	2,000 ft ²
Region 7	Stratum C1 Drained	26,32,31,27	1,000 ft ²
Region 8	Stratum C2	27,31,30,28	2,900 ft ²
Region 9	Stratum B2 Lower - Above WT	24,23,29,36,5	1,100.5 ft ²

Current Slip Surface

Slip Surface: 2,644
Factor of Safety: 2.2
Volume: 540.31031 ft³
Weight: 66,207.027 lbf
Resisting Moment: 1,720,385.9 lbf-ft
Activating Moment: 773,692.91 lbf-ft
Resisting Force: 46,131.02 lbf
Activating Force: 20,749.041 lbf
Slip Rank: 1 of 4,805 slip surfaces
Exit: (-16.189416, 24) ft
Entry: (-49.930795, 49.443483) ft
Radius: 33.150428 ft
Center: (-17.680679, 57.116869) ft

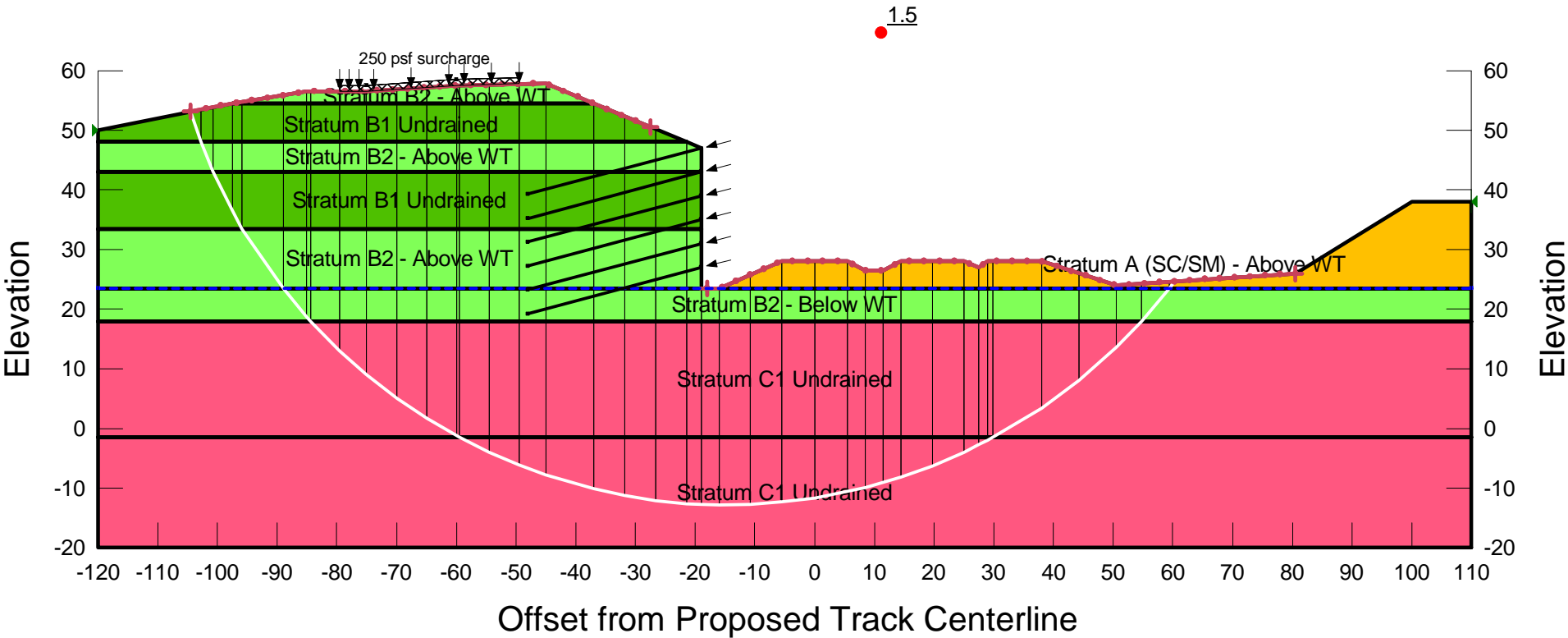
Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-49.479518 ft	47.888489 ft	-1,521.8417 psf	180.88525 psf	88.22363 psf	50 psf
Slice 2	-48.576965 ft	45.166748 ft	-1,352.005 psf	362.68567 psf	176.89362 psf	50 psf
Slice 3	-47.312844 ft	42.367012 ft	-1,177.3016 psf	522.65682 psf	277.90156 psf	50 psf
Slice 4	-46.285089 ft	40.367012 ft	-1,052.5016 psf	507.81389 psf	270.00944 psf	50 psf
Slice 5	-45.75644 ft	39.5 ft	-998.4 psf	570.29747 psf	278.15266 psf	50 psf
Slice 6	-45.221351 ft	38.669537 ft	-946.57914 psf	584.03771 psf	408.94761 psf	50 psf
Slice 7	-44.423077 ft	37.550561 ft	-876.75501 psf	659.40518 psf	461.72048 psf	50 psf

Slice 8	-43.269231 ft	36.060932 ft	-783.80218 psf	765.5226 psf	536.02469 psf	50 psf
Slice 9	-42.115385 ft	34.730117 ft	-700.75932 psf	870.68877 psf	609.66284 psf	50 psf
Slice 10	-40.961538 ft	33.530956 ft	-625.93163 psf	978.39179 psf	685.0773 psf	50 psf
Slice 11	-39.807692 ft	32.444099 ft	-558.11175 psf	1,091.3613 psf	764.17939 psf	50 psf
Slice 12	-38.653846 ft	31.455187 ft	-496.40364 psf	1,211.7874 psf	848.50268 psf	50 psf
Slice 13	-37.5 ft	30.553224 ft	-440.12116 psf	1,341.4146 psf	939.26858 psf	50 psf
Slice 14	-36.346154 ft	29.729582 ft	-388.72595 psf	1,505.333 psf	1,054.0455 psf	50 psf
Slice 15	-35.192308 ft	28.97736 ft	-341.78725 psf	1,658.3743 psf	1,161.2062 psf	50 psf
Slice 16	-34.038462 ft	28.290947 ft	-298.95508 psf	1,822.5601 psf	1,276.1703 psf	50 psf
Slice 17	-32.884615 ft	27.665729 ft	-259.9415 psf	1,997.314 psf	1,398.5343 psf	50 psf
Slice 18	-31.730769 ft	27.097874 ft	-224.50732 psf	2,181.1613 psf	1,527.2656 psf	50 psf
Slice 19	-30.576923 ft	26.584173 ft	-192.45239 psf	2,371.5629 psf	1,660.5862 psf	50 psf
Slice 20	-29.45 ft	26.131585 ft	-164.21092 psf	2,636.0174 psf	1,845.7593 psf	50 psf
Slice 21	-28.35 ft	25.735681 ft	-139.50647 psf	2,802.6089 psf	1,962.4079 psf	50 psf
Slice 22	-27.25 ft	25.382834 ft	-117.48886 psf	2,958.8926 psf	2,071.8389 psf	50 psf
Slice 23	-26.15 ft	25.071622 ft	-98.069228 psf	3,098.7606 psf	2,169.7756 psf	50 psf
Slice 24	-25.05 ft	24.80084 ft	-81.172401 psf	3,215.8216 psf	2,251.7426 psf	50 psf
Slice 25	-23.95 ft	24.569476 ft	-66.735332 psf	3,303.9177 psf	2,313.4281 psf	50 psf
Slice 26	-22.85 ft	24.376696 ft	-54.705809 psf	3,357.7383 psf	2,351.1136 psf	50 psf
Slice 27	-21.75 ft	24.221818 ft	-45.041454 psf	3,373.4478 psf	2,362.1136 psf	50 psf
Slice 28	-20.65 ft	24.10431 ft	-37.708938 psf	3,349.2182 psf	2,345.1478 psf	50 psf
Slice 29	-19.55 ft	24.023772 ft	-32.683393 psf	5,379.8561 psf	3,767.0158 psf	50 psf
Slice 30	-18.297354 ft	23.979629 ft	-29.928822 psf	8.251714 psf	4.7641293 psf	50 psf
Slice 31	-16.892062 ft	23.983276 ft	-30.156438 psf	4.6439422 psf	2.6811813 psf	50 psf

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8267+00, Short Term
 Section D-D'

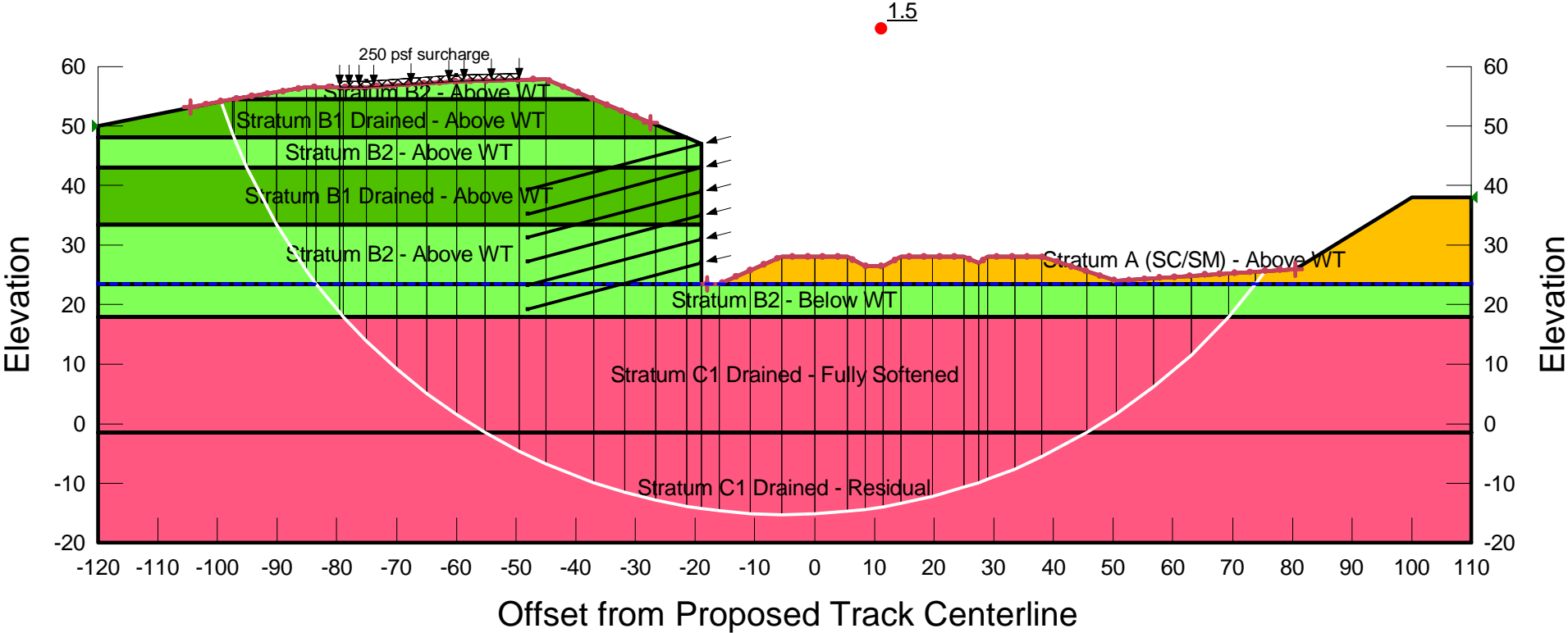
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Orange	Stratum A (SC/SM) - Above WT	Mohr-Coulomb	120	50	30
Dark Green	Stratum B1 Undrained	Mohr-Coulomb	120	1,000	0
Light Green	Stratum B2 - Above WT	Mohr-Coulomb	125	50	35
Light Green	Stratum B2 - Below WT	Mohr-Coulomb	125	0	35
Pink	Stratum C1 Undrained	Mohr-Coulomb	120	1,000	0



Units for Offset and Elevation are in feet.

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8267+00, Long Term
 Section D-D'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi Fn	Phi' (°)
■	Stratum A (SC/SM) - Above WT	Mohr-Coulomb	120	50		30
■	Stratum B1 Drained - Above WT	Mohr-Coulomb	120	50		26
■	Stratum B2 - Above WT	Mohr-Coulomb	125	50		35
■	Stratum B2 - Below WT	Mohr-Coulomb	125	0		35
■	Stratum C1 Drained - Fully Softened	Spatial Mohr-Coulomb	120	0	Fully Softened	
■	Stratum C1 Drained - Residual	Mohr-Coulomb	120	0		13



Units for Offset and Elevation are in feet.

8267+00, Short Term

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File Information

File Version: 9.00
Created By: [Fernanda Madrona](#)
Last Edited By: [Garden, Alistair S](#)
Revision Number: 86
Date: 06/05/2020
Time: 10:37:59 AM
Tool Version: 9.0.3.15488
File Name: [SECTION D-D' \(BH-03\).gsz](#)
Directory: [C:\Users\asgarden\Desktop\WFH\Arkendale\Global Stability\](#)
Last Solved Date: 06/05/2020
Last Solved Time: 10:38:12 AM

Project Settings

Unit System: [U.S. Customary Units](#)

Analysis Settings

8267+00, Short Term

Kind: [SLOPE/W](#)
Method: [Morgenstern-Price](#)
Settings
Side Function
Interslice force function option: [Half-Sine](#)
PWP Conditions from: [Piezometric Line](#)
Apply Phreatic Correction: [No](#)
Use Staged Rapid Drawdown: [No](#)
Unit Weight of Water: [62.4 pcf](#)
Slip Surface
Direction of movement: [Left to Right](#)
Use Passive Mode: [No](#)
Slip Surface Option: [Entry and Exit](#)
Critical slip surfaces saved: [1](#)
Optimize Critical Slip Surface Location: [No](#)
Tension Crack Option: [\(none\)](#)
Distribution
F of S Calculation Option: [Constant](#)
Advanced
Geometry Settings
Minimum Slip Surface Depth: [0.1 ft](#)
Number of Slices: [30](#)

Factor of Safety Convergence Settings
Maximum Number of Iterations: [100](#)
Tolerable difference in F of S: [0.001](#)
Solution Settings
Search Method: [Linear Search](#)
Must Obtain at Lambda Factor of Safety: [0.2](#)
Lambda
Lambda 1: [-1](#)
Lambda 2: [-0.8](#)
Lambda 3: [-0.6](#)
Lambda 4: [-0.4](#)
Lambda 5: [-0.2](#)
Lambda 6: [0](#)
Lambda 7: [0.2](#)
Lambda 8: [0.4](#)
Lambda 9: [0.6](#)
Lambda 10: [0.8](#)
Lambda 11: [1](#)

Materials

Stratum A (SC/SM) - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [30 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-104.5, 53.1\) ft](#)
Left-Zone Right Coordinate: [\(-27.49407, 50.52831\) ft](#)
Left-Zone Increment: [30](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-17.94595, 23.5\) ft](#)
Right-Zone Right Coordinate: [\(80.5, 26\) ft](#)
Right-Zone Increment: [40](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-120, 50\) ft](#)
Right Coordinate: [\(110, 38.0625\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-120 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 47\) ft](#)
Inside Point: [\(-47.97777, 39.23543\) ft](#)
Length: [29.999995 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [196.6637 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)
Required Length: [0 ft](#)
Governing Component: [\(none\)](#)

Reinforcement 2

Type: [Nail](#)
Outside Point: [\(-19, 43\) ft](#)
Inside Point: [\(-47.97777, 35.23543\) ft](#)
Length: [29.999995 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [196.6637 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)

Required Length: 0 ft
Governing Component: (none)

Reinforcement 3

Type: Nail
Outside Point: (-19, 39) ft
Inside Point: (-47.97777, 31.23543) ft
Length: 29.999995 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,252 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 196.6637 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 4

Type: Nail
Outside Point: (-19, 35) ft
Inside Point: (-47.97777, 27.23543) ft
Length: 29.999995 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,252 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 196.6637 lbf/ft
Max. Pullout Force: 5,266.6667 lbf

Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 5

Type: Nail
Outside Point: (-19, 31) ft
Inside Point: (-47.97777, 23.23543) ft
Length: 29.999995 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 6

Type: Nail
Outside Point: (-19, 27) ft
Inside Point: (-47.97777, 19.23543) ft
Length: 29.999995 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf

Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1
Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-79.5 ft	57.5 ft
	-75 ft	57.5 ft
	-60 ft	58.5 ft
	-49.5 ft	58.8 ft

Points

	X	Y
Point 1	-75 ft	56.5 ft
Point 2	-60 ft	57.5 ft
Point 3	-19 ft	23.5 ft
Point 4	-16 ft	23.5 ft
Point 5	-5.5 ft	28 ft
Point 6	5.5 ft	28 ft
Point 7	8.5 ft	26.5 ft
Point 8	14.5 ft	28 ft
Point 9	25 ft	28 ft
Point 10	27.5 ft	27 ft
Point 11	29 ft	28 ft
Point 12	38 ft	28 ft
Point 13	50.5 ft	24 ft
Point 14	80.5 ft	26 ft
Point 15	100 ft	38 ft
Point 16	-19 ft	33.5 ft
Point 17	-19 ft	43 ft

Point 18	-19 ft	47 ft
Point 19	110 ft	-20 ft
Point 20	110 ft	18 ft
Point 21	110 ft	23.5 ft
Point 22	110 ft	38.0625 ft
Point 23	-85 ft	56.5 ft
Point 24	11.5 ft	26.5 ft
Point 25	-45 ft	57.8 ft
Point 26	-21.41673 ft	48.00387 ft
Point 27	-37.01472 ft	54.48304 ft
Point 28	110 ft	-1.5 ft
Point 29	-120 ft	-20 ft
Point 30	-120 ft	50 ft
Point 31	-120 ft	-1.5 ft
Point 32	-120 ft	18 ft
Point 33	-120 ft	33.5 ft
Point 34	-120 ft	43 ft
Point 35	-120 ft	48 ft
Point 36	-97.5 ft	54.5 ft
Point 37	-120 ft	23.5 ft

Regions

	Material	Points	Area
Region 1	Stratum B1 Undrained	16,17,34,33	959.5 ft²
Region 2	Stratum B2 - Below WT	20,21,4,3,37,32	1,265 ft²
Region 3	Stratum A (SC/SM) - Above WT	4,5,6,7,24,8,9,10,11,12,13,14,15,22,21	595.69 ft²

Region 4	Stratum B2 - Above WT	17,18,26,35,34	503.99 ft ²
Region 5	Stratum C1 Undrained	19,28,31,29	4,255 ft ²
Region 6	Stratum B1 Undrained	26,27,36,30,35	538.67 ft ²
Region 7	Stratum B2 - Above WT	27,25,2,1,23,36	130.87 ft ²
Region 8	Stratum B2 - Above WT	3,16,33,37	1,010 ft ²
Region 9	Stratum C1 Undrained	28,20,32,31	4,485 ft ²

Current Slip Surface

Slip Surface: 164

Factor of Safety: 1.5

Volume: 6,509.8224 ft³

Weight: 791,520.74 lbf

Resisting Moment: 19,554,202 lbf-ft

Activating Moment: 13,211,232 lbf-ft

Resisting Force: 166,723.71 lbf

Activating Force: 113,325.95 lbf

Slip Rank: 1 of 6,355 slip surfaces

Exit: (60.292023, 24.652802) ft

Entry: (-104.5, 53.1) ft

Radius: 93.998944 ft

Center: (-14.798435, 81.196807) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-103.62028 ft	50.550339 ft	-1,687.9411 psf	-1,623.0658 psf	-0 psf	1,000 psf
Slice 2	-101.71367 ft	45.500339 ft	-1,372.8211 psf	424.96036 psf	297.56044 psf	50 psf
Slice 3	-99.093383 ft	39.758683 ft	-1,014.5418 psf	387.39207 psf	0 psf	1,000 psf
Slice 4	-96.648649 ft	35.008683 ft	-718.14181 psf	1,180.0561 psf	0 psf	1,000 psf
Slice 5	-92.402044 ft	28.5 ft	-312 psf	1,888.0695 psf	1,322.0405 psf	50 psf
Slice 6	-87.003395 ft	21.093237 ft	150.18198 psf	2,775.6455 psf	1,838.3693 psf	0 psf
Slice 7	-84.691332 ft	18.343237 ft	321.78198 psf	3,153.4958 psf	1,982.7874 psf	0 psf
Slice 8	-81.941332 ft	15.50475 ft	498.9036 psf	4,256.452 psf	0 psf	1,000 psf

Slice 9	-77.25 ft	11.007541 ft	779.52943 psf	5,107.1265 psf	0 psf	1,000 psf
Slice 10	-72.5 ft	7.0598074 ft	1,025.868 psf	5,657.4045 psf	0 psf	1,000 psf
Slice 11	-67.5 ft	3.4200318 ft	1,252.99 psf	6,189.2928 psf	0 psf	1,000 psf
Slice 12	-62.5 ft	0.2527431 ft	1,450.6288 psf	6,663.0297 psf	0 psf	1,000 psf
Slice 13	-59.743341 ft	-1.3602724 ft	1,551.281 psf	6,907.4926 psf	0 psf	1,000 psf
Slice 14	-56.990012 ft	-2.754753 ft	1,638.2966 psf	7,117.228 psf	0 psf	1,000 psf
Slice 15	-51.996671 ft	-5.0858721 ft	1,783.7584 psf	7,475.5788 psf	0 psf	1,000 psf
Slice 16	-47.25 ft	-6.9902061 ft	1,902.5889 psf	7,508.024 psf	0 psf	1,000 psf
Slice 17	-41.00736 ft	-8.9786101 ft	2,026.6653 psf	7,624.1827 psf	0 psf	1,000 psf
Slice 18	-34.415055 ft	-10.694016 ft	2,133.7066 psf	7,580.7199 psf	0 psf	1,000 psf
Slice 19	-29.215725 ft	-11.652651 ft	2,193.5254 psf	7,506.6145 psf	0 psf	1,000 psf
Slice 20	-24.016395 ft	-12.312586 ft	2,234.7054 psf	7,396.5155 psf	0 psf	1,000 psf
Slice 21	-20.208365 ft	-12.638522 ft	2,255.0438 psf	7,293.8866 psf	0 psf	1,000 psf
Slice 22	-17.5 ft	-12.751323 ft	2,262.0825 psf	4,393.5512 psf	0 psf	1,000 psf
Slice 23	-13.375 ft	-12.754686 ft	2,262.2924 psf	4,576.5796 psf	0 psf	1,000 psf
Slice 24	-8.125 ft	-12.528009 ft	2,248.1478 psf	4,879.7706 psf	0 psf	1,000 psf
Slice 25	-2.75 ft	-11.985529 ft	2,214.297 psf	5,009.9308 psf	0 psf	1,000 psf
Slice 26	2.75 ft	-11.107137 ft	2,159.4853 psf	4,962.9977 psf	0 psf	1,000 psf
Slice 27	7 ft	-10.226668 ft	2,104.5441 psf	4,809.6534 psf	0 psf	1,000 psf
Slice 28	10 ft	-9.4586985 ft	2,056.6228 psf	4,655.7045 psf	0 psf	1,000 psf
Slice 29	13 ft	-8.583941 ft	2,002.0379 psf	4,669.69 psf	0 psf	1,000 psf
Slice 30	17.125 ft	-7.1712066 ft	1,913.8833 psf	4,628.0806 psf	0 psf	1,000 psf
Slice 31	22.375 ft	-5.0920549 ft	1,784.1442 psf	4,423.3534 psf	0 psf	1,000 psf
Slice 32	26.25 ft	-3.354341 ft	1,675.7109 psf	4,185.9028 psf	0 psf	1,000 psf

Slice 33	28.25 ft	-2.3610883 ft	1,613.7319 psf	4,082.8965 psf	0 psf	1,000 psf
Slice 34	29.444907 ft	-1.7373468 ft	1,574.8104 psf	4,078.4521 psf	0 psf	1,000 psf
Slice 35	33.944907 ft	0.96355206 ft	1,406.2744 psf	3,791.0293 psf	0 psf	1,000 psf
Slice 36	41.125 ft	5.7432403 ft	1,108.0218 psf	3,159.1152 psf	0 psf	1,000 psf
Slice 37	47.375 ft	10.82012 ft	791.22452 psf	2,375.5874 psf	0 psf	1,000 psf
Slice 38	52.642897 ft	15.790432 ft	481.07706 psf	1,751.5192 psf	0 psf	1,000 psf
Slice 39	57.097857 ft	20.75 ft	171.6 psf	837.38662 psf	466.18881 psf	0 psf
Slice 40	59.850971 ft	24.076401 ft	-35.967408 psf	224.5416 psf	129.63915 psf	50 psf

8267+00, Long Term

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File Information

File Version: 9.00
Created By: [Fernanda Madrona](#)
Last Edited By: [Garden, Alistair S](#)
Revision Number: 86
Date: 06/05/2020
Time: 10:37:59 AM
Tool Version: 9.0.3.15488
File Name: [SECTION D-D' \(BH-03\).gsz](#)
Directory: [C:\Users\asgarden\Desktop\WFH\Arkendale\Global Stability\](#)
Last Solved Date: 06/05/2020
Last Solved Time: 10:38:20 AM

Project Settings

Unit System: [U.S. Customary Units](#)

Analysis Settings

8267+00, Long Term

Kind: [SLOPE/W](#)
Method: [Morgenstern-Price](#)
Settings
Side Function
Interslice force function option: [Half-Sine](#)
PWP Conditions from: [Piezometric Line](#)
Apply Phreatic Correction: [No](#)
Use Staged Rapid Drawdown: [No](#)
Unit Weight of Water: [62.4 pcf](#)
Slip Surface
Direction of movement: [Left to Right](#)
Use Passive Mode: [No](#)
Slip Surface Option: [Entry and Exit](#)
Critical slip surfaces saved: [1](#)
Optimize Critical Slip Surface Location: [No](#)
Tension Crack Option: [\(none\)](#)
Distribution
F of S Calculation Option: [Constant](#)
Advanced
Geometry Settings
Minimum Slip Surface Depth: [0.1 ft](#)
Number of Slices: [30](#)

Factor of Safety Convergence Settings
Maximum Number of Iterations: [100](#)
Tolerable difference in F of S: [0.001](#)
Solution Settings
Search Method: [Linear Search](#)
Must Obtain at Lambda Factor of Safety: [0.2](#)
Lambda
Lambda 1: [-1](#)
Lambda 2: [-0.8](#)
Lambda 3: [-0.6](#)
Lambda 4: [-0.4](#)
Lambda 5: [-0.2](#)
Lambda 6: [0](#)
Lambda 7: [0.2](#)
Lambda 8: [0.4](#)
Lambda 9: [0.6](#)
Lambda 10: [0.8](#)
Lambda 11: [1](#)

Materials

Stratum A (SC/SM) - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion: [50 psf](#)
Phi: [30 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion: [50 psf](#)
Phi: [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Drained - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion: [50 psf](#)
Phi: [26 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Drained - Residual

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi': [13 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Drained - Fully Softened

Model: [Spatial Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi Fn: [Fully Softened](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-104.5, 53.1\) ft](#)
Left-Zone Right Coordinate: [\(-27.49407, 50.52831\) ft](#)
Left-Zone Increment: [30](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-17.94595, 23.5\) ft](#)
Right-Zone Right Coordinate: [\(80.5, 26\) ft](#)
Right-Zone Increment: [40](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-120, 50\) ft](#)
Right Coordinate: [\(110, 38.0625\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-120 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 47\) ft](#)
Inside Point: [\(-47.97777, 39.23543\) ft](#)
Length: [29.999995 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [196.6637 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)
Required Length: [0 ft](#)
Governing Component: [\(none\)](#)

Reinforcement 2

Type: [Nail](#)
Outside Point: [\(-19, 43\) ft](#)
Inside Point: [\(-47.97777, 35.23543\) ft](#)
Length: [29.999995 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)

Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 196.6637 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 3

Type: Nail
 Outside Point: (-19, 39) ft
 Inside Point: (-47.97777, 31.23543) ft
 Length: 29.999995 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,252 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 196.6637 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 4

Type: Nail
 Outside Point: (-19, 35) ft
 Inside Point: (-47.97777, 27.23543) ft
 Length: 29.999995 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,252 psf

Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 196.6637 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 5

Type: Nail
 Outside Point: (-19, 31) ft
 Inside Point: (-47.97777, 23.23543) ft
 Length: 29.999995 ft
 Direction: 15 °
 F of S Dependent: No
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 6

Type: Nail
 Outside Point: (-19, 27) ft
 Inside Point: (-47.97777, 19.23543) ft
 Length: 29.999995 ft
 Direction: 15 °

F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1
Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-79.5 ft	57.5 ft
	-75 ft	57.5 ft
	-60 ft	58.5 ft
	-49.5 ft	58.8 ft

Phi Functions

Fully Softened
Model: Spline Data Point Function
Function: Phi vs. Y
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 23.461538
Data Points: Y (ft), Phi (°)
Data Point: (-1.5, 23)
Data Point: (18, 29)

Points

	X	Y
Point 1	-75 ft	56.5 ft
Point 2	-60 ft	57.5 ft
Point 3	-19 ft	23.5 ft
Point 4	-16 ft	23.5 ft
Point 5	-5.5 ft	28 ft
Point 6	5.5 ft	28 ft
Point 7	8.5 ft	26.5 ft
Point 8	14.5 ft	28 ft
Point 9	25 ft	28 ft
Point 10	27.5 ft	27 ft
Point 11	29 ft	28 ft
Point 12	38 ft	28 ft
Point 13	50.5 ft	24 ft
Point 14	80.5 ft	26 ft
Point 15	100 ft	38 ft
Point 16	-19 ft	33.5 ft
Point 17	-19 ft	43 ft
Point 18	-19 ft	47 ft
Point 19	110 ft	-20 ft
Point 20	110 ft	18 ft
Point 21	110 ft	23.5 ft
Point 22	110 ft	38.0625 ft
Point 23	-85 ft	56.5 ft
Point 24	11.5 ft	26.5 ft
Point 25	-45 ft	57.8 ft
Point 26	-21.41673 ft	48.00387 ft
Point 27	-37.01472 ft	54.48304 ft
Point 28	110 ft	-1.5 ft
Point 29	-120 ft	-20 ft
Point 30	-120 ft	50 ft
Point 31	-120 ft	-1.5 ft
Point 32	-120 ft	18 ft
Point 33	-120 ft	33.5 ft
Point 34	-120 ft	43 ft
Point 35	-120 ft	48 ft
Point 36	-97.5 ft	54.5 ft
Point 37	-120 ft	23.5 ft

Regions

	Material	Points	Area
--	----------	--------	------

Region 1	Stratum B1 Drained - Above WT	16,17,34,33	959.5 ft ²
Region 2	Stratum B2 - Below WT	20,21,4,3,37,32	1,265 ft ²
Region 3	Stratum A (SC/SM) - Above WT	4,5,6,7,24,8,9,10,11,12,13,14,15,22,21	595.69 ft ²
Region 4	Stratum B2 - Above WT	17,18,26,35,34	503.99 ft ²
Region 5	Stratum C1 Drained - Residual	19,28,31,29	4,255 ft ²
Region 6	Stratum B1 Drained - Above WT	26,27,36,30,35	538.67 ft ²
Region 7	Stratum B2 - Above WT	27,25,2,1,23,36	130.87 ft ²
Region 8	Stratum B2 - Above WT	3,16,33,37	1,010 ft ²
Region 9	Stratum C1 Drained - Fully Softened	28,20,32,31	4,485 ft ²

Current Slip Surface

Slip Surface: 604
Factor of Safety: 1.5
Volume: 6,863.1541 ft³
Weight: 833,750.2 lbf
Resisting Moment: 21,527,246 lbf-ft
Activating Moment: 14,595,089 lbf-ft
Resisting Force: 174,059.56 lbf
Activating Force: 119,321.92 lbf
Slip Rank: 1 of 6,355 slip surfaces
Exit: (75.448006, 25.6632) ft
Entry: (-99.349333, 54.130133) ft
Radius: 99.113775 ft
Center: (-4.7938513, 83.842103) ft

Slip Slices

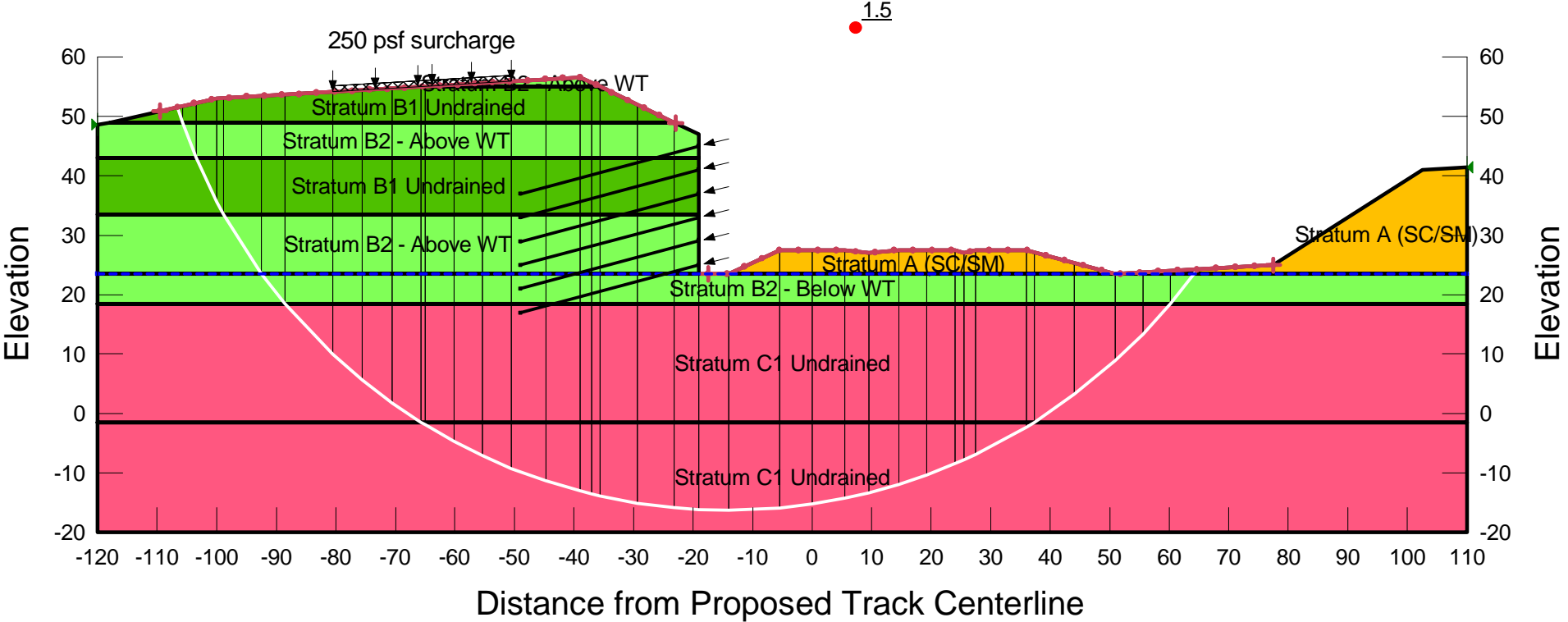
	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-98.424667 ft	51.456783 ft	-1,744.5033 psf	124.81126 psf	60.874519 psf	50 psf
Slice 2	-97.35014 ft	48.392164 ft	-1,553.271 psf	345.69081 psf	168.60467 psf	50 psf
Slice 3	-96.150867 ft	45.500448 ft	-1,372.8279 psf	484.15979 psf	339.01233 psf	50 psf
Slice 4	-92.636096 ft	38.25 ft	-920.4 psf	1,207.9458 psf	589.15452 psf	50 psf
Slice 5	-87.58537 ft	29.556991 ft	-377.95625 psf	1,814.4335 psf	1,270.48 psf	50 psf

Slice 6	-84.210953 ft	24.556991 ft	-65.956246 psf	2,317.5341 psf	1,622.7548 psf	50 psf
Slice 7	-81.460953 ft	21.103692 ft	149.52963 psf	2,744.2897 psf	1,816.8705 psf	0 psf
Slice 8	-79.188651 ft	18.353692 ft	321.12963 psf	3,247.3443 psf	2,048.9575 psf	0 psf
Slice 9	-76.938651 ft	15.94021 ft	471.73088 psf	3,793.7421 psf	1,793.6743 psf	0 psf
Slice 10	-72.5 ft	11.539356 ft	746.34417 psf	4,414.7153 psf	1,870.1052 psf	0 psf
Slice 11	-67.5 ft	7.1540954 ft	1,019.9844 psf	5,062.8848 psf	1,942.4845 psf	0 psf
Slice 12	-62.5 ft	3.3183118 ft	1,259.3373 psf	5,649.3457 psf	1,999.0283 psf	0 psf
Slice 13	-57.59745 ft	0.013362452 ft	1,465.5662 psf	6,166.8169 psf	2,040.8115 psf	0 psf
Slice 14	-52.34745 ft	-3.0581826 ft	1,657.2306 psf	6,932.4355 psf	1,217.877 psf	0 psf
Slice 15	-47.25 ft	-5.6833945 ft	1,821.0438 psf	7,069.7094 psf	1,211.7499 psf	0 psf
Slice 16	-41.00736 ft	-8.3192752 ft	1,985.5228 psf	7,278.2068 psf	1,221.9124 psf	0 psf
Slice 17	-34.415055 ft	-10.702611 ft	2,134.2429 psf	7,343.6198 psf	1,202.6794 psf	0 psf
Slice 18	-29.215725 ft	-12.178296 ft	2,226.3256 psf	7,357.2742 psf	1,184.5728 psf	0 psf
Slice 19	-24.016395 ft	-13.353635 ft	2,299.6668 psf	7,336.7595 psf	1,162.9045 psf	0 psf
Slice 20	-20.208365 ft	-14.058034 ft	2,343.6213 psf	7,300.5967 psf	1,144.408 psf	0 psf
Slice 21	-17.5 ft	-14.442212 ft	2,367.594 psf	4,494.0206 psf	490.92427 psf	0 psf
Slice 22	-13.375 ft	-14.864338 ft	2,393.9347 psf	4,724.9949 psf	538.16766 psf	0 psf
Slice 23	-8.125 ft	-15.180851 ft	2,413.6851 psf	5,097.0201 psf	619.4967 psf	0 psf
Slice 24	-2.75 ft	-15.212414 ft	2,415.6546 psf	5,306.5437 psf	667.41433 psf	0 psf
Slice 25	2.75 ft	-14.94567 ft	2,399.0098 psf	5,344.7347 psf	680.07418 psf	0 psf
Slice 26	7 ft	-14.55588 ft	2,374.6869 psf	5,256.2226 psf	665.25492 psf	0 psf
Slice 27	10 ft	-14.149636 ft	2,349.3373 psf	5,147.1226 psf	645.91963 psf	0 psf
Slice 28	13 ft	-13.649405 ft	2,318.1229 psf	5,213.6704 psf	668.48982 psf	0 psf
Slice 29	17.125 ft	-12.780146 ft	2,263.8811 psf	5,245.3481 psf	688.3259 psf	0 psf

Slice 30	22.375 ft	-11.436136 ft	2,180.0149 psf	5,128.7014 psf	680.75791 psf	0 psf
Slice 31	26.25 ft	-10.275308 ft	2,107.5792 psf	4,951.0302 psf	656.46237 psf	0 psf
Slice 32	28.25 ft	-9.597778 ft	2,065.3013 psf	4,880.9833 psf	650.05141 psf	0 psf
Slice 33	31.25 ft	-8.4538694 ft	1,993.9215 psf	4,823.0716 psf	653.16078 psf	0 psf
Slice 34	35.75 ft	-6.56617 ft	1,876.129 psf	4,610.0374 psf	631.17249 psf	0 psf
Slice 35	41.803599 ft	-3.5285755 ft	1,686.5831 psf	4,083.4172 psf	553.35276 psf	0 psf
Slice 36	48.053599 ft	0.042805943 ft	1,463.7289 psf	3,587.826 psf	922.46909 psf	0 psf
Slice 37	53.6316 ft	3.8735763 ft	1,224.6888 psf	3,033.6933 psf	830.26748 psf	0 psf
Slice 38	59.8948 ft	8.8633596 ft	913.32636 psf	2,474.2875 psf	767.70663 psf	0 psf
Slice 39	66.158 ft	14.782589 ft	543.96643 psf	1,767.8658 psf	651.03364 psf	0 psf
Slice 40	71.561902 ft	20.75 ft	171.6 psf	1,157.8874 psf	690.60585 psf	0 psf
Slice 41	74.641104 ft	24.5816 ft	-67.491852 psf	358.60946 psf	207.04327 psf	50 psf

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8267+50, Short Term
 Section E-E'

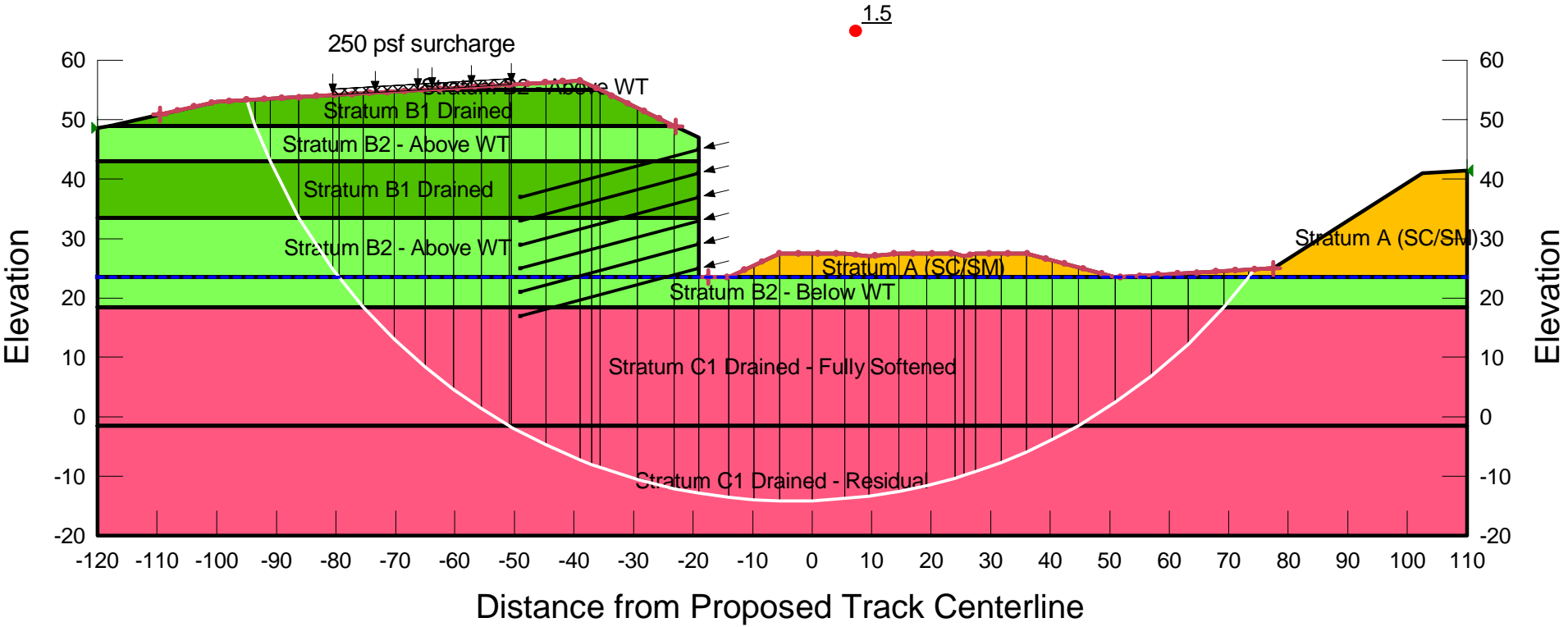
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Stratum A (SC/SM)	Mohr-Coulomb	120	50	30
	Stratum B1 Undrained	Mohr-Coulomb	120	1,000	0
	Stratum B2 - Above WT	Mohr-Coulomb	125	50	35
	Stratum B2 - Below WT	Mohr-Coulomb	125	0	35
	Stratum C1 Undrained	Mohr-Coulomb	120	1,000	0



Units for Distance and Elevation are in feet.

Arkendale to Powells Creek Third Track Project
Soil Nail Wall - Global Stability Analysis
Station 8267+50, Long Term
Section E-E'

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi Fn	Phi' (°)
■	Stratum A (SC/SM)	Mohr-Coulomb	120	50		30
■	Stratum B1 Drained	Mohr-Coulomb	120	50		26
■	Stratum B2 - Above WT	Mohr-Coulomb	125	50		35
■	Stratum B2 - Below WT	Mohr-Coulomb	125	0		35
■	Stratum C1 Drained - Fully Softened	Spatial Mohr-Coulomb	120	0	Fully Softened	
■	Stratum C1 Drained - Residual	Mohr-Coulomb	120	0		13



Units for Distance and Elevation are in feet.

8267+50, Short Term

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File Information

File Version: 9.00
Created By: [Fernanda Madrona](#)
Last Edited By: [Garden, Alistair S](#)
Revision Number: 89
Date: 05/28/2020
Time: 04:33:38 PM
Tool Version: 9.0.3.15488
File Name: [SECTION E-E' \(BH-03\).gsz](#)
Directory: [C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\](#)
Last Solved Date: 05/28/2020
Last Solved Time: 04:33:56 PM

Project Settings

Unit System: [U.S. Customary Units](#)

Analysis Settings

8267+50, Short Term

Kind: [SLOPE/W](#)
Method: [Morgenstern-Price](#)
Settings
Side Function
Interslice force function option: [Half-Sine](#)
PWP Conditions from: [Piezometric Line](#)
Apply Phreatic Correction: [No](#)
Use Staged Rapid Drawdown: [No](#)
Unit Weight of Water: [62.4 pcf](#)
Slip Surface
Direction of movement: [Left to Right](#)
Use Passive Mode: [No](#)
Slip Surface Option: [Entry and Exit](#)
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: [No](#)
Tension Crack Option: [\(none\)](#)
Distribution
F of S Calculation Option: [Constant](#)
Advanced
Geometry Settings
Minimum Slip Surface Depth: [0.1 ft](#)
Number of Slices: [30](#)

Factor of Safety Convergence Settings
Maximum Number of Iterations: [100](#)
Tolerable difference in F of S: [0.001](#)

Solution Settings
Search Method: [Linear Search](#)
Must Obtain at Lambda Factor of Safety: [0.2](#)
Lambda
Lambda 1: [-1](#)
Lambda 2: [-0.8](#)
Lambda 3: [-0.6](#)
Lambda 4: [-0.4](#)
Lambda 5: [-0.2](#)
Lambda 6: [0](#)
Lambda 7: [0.2](#)
Lambda 8: [0.4](#)
Lambda 9: [0.6](#)
Lambda 10: [0.8](#)
Lambda 11: [1](#)

Materials

Stratum A (SC/SM)

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [30 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion: [1,000 psf](#)
Phi: [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion: [0 psf](#)
Phi: [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-109.5, 50.88889\) ft](#)
Left-Zone Right Coordinate: [\(-22.94181, 48.89207\) ft](#)
Left-Zone Increment: [30](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-17.5, 23.5\) ft](#)
Right-Zone Right Coordinate: [\(77.5, 25\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-120, 48.625\) ft](#)
Right Coordinate: [\(110, 41.42857\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-120 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 45\) ft](#)
Inside Point: [\(-48.9437, 36.97661\) ft](#)
Length: [30.999999 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252.8 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [196.78936 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)
Required Length: [0 ft](#)
Governing Component: [\(none\)](#)

Reinforcement 2

Type: [Nail](#)
Outside Point: [\(-19, 41\) ft](#)
Inside Point: [\(-48.9437, 32.97661\) ft](#)
Length: [30.999999 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252.8 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [196.78936 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)

Required Length: 0 ft
 Governing Component: (none)

Reinforcement 3

Type: Nail
 Outside Point: (-19, 37) ft
 Inside Point: (-48.9437, 28.97661) ft
 Length: 30.999999 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,252.8 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 196.78936 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 4

Type: Nail
 Outside Point: (-19, 33) ft
 Inside Point: (-48.9437, 24.97661) ft
 Length: 30.999999 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf

Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 5

Type: Nail
 Outside Point: (-19, 29) ft
 Inside Point: (-48.9437, 20.97661) ft
 Length: 30.999999 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 6

Type: Nail
 Outside Point: (-19, 25) ft
 Inside Point: (-48.9437, 16.97661) ft
 Length: 30.999999 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1
 Shear Force: 0 lbf

Shear Reduction Factor: 1
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 9,115.645 lbf
Factored Tensile Capacity: 9,480 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1
Surcharge (Unit Weight): 250 pcf
Direction: [Vertical](#)

Coordinates

	X	Y
	-80.5 ft	55.15 ft
	-50.5 ft	56.9 ft

Points

	X	Y
Point 1	-100 ft	53 ft
Point 2	-65 ft	55 ft
Point 3	-19 ft	47 ft
Point 4	-19 ft	23.5 ft
Point 5	-14 ft	23.5 ft
Point 6	-5.5 ft	27.5 ft
Point 7	5.5 ft	27.5 ft
Point 8	9.5 ft	27 ft
Point 9	14.5 ft	27.5 ft
Point 10	24 ft	27.5 ft
Point 11	25.5 ft	27 ft
Point 12	27.5 ft	27.5 ft
Point 13	36 ft	27.5 ft
Point 14	51 ft	23.5 ft
Point 15	77.5 ft	25 ft
Point 16	102.5 ft	41 ft
Point 17	-118 ft	49 ft
Point 18	-19 ft	43 ft
Point 19	-19 ft	33.5 ft

Point 20	-19 ft	29.4 ft
Point 21	-37 ft	55 ft
Point 22	-39 ft	56.6 ft
Point 23	-23.16667 ft	49 ft
Point 24	-35.66667 ft	55 ft
Point 25	-120 ft	-20 ft
Point 26	-120 ft	-1.5 ft
Point 27	-120 ft	18.5 ft
Point 28	-120 ft	23.5 ft
Point 29	-120 ft	33.5 ft
Point 30	-120 ft	43 ft
Point 31	-120 ft	48.625 ft
Point 32	110 ft	-20 ft
Point 33	110 ft	-1.5 ft
Point 34	110 ft	18.5 ft
Point 35	110 ft	23.5 ft
Point 36	110 ft	41.42857 ft

Regions

	Material	Points	Area
Region 1	Stratum B1 Undrained	2,1,17,23,24,21	424.5 ft²
Region 2	Stratum B2 - Below WT	4,28,27,34,35,14,5	1,150 ft²
Region 3	Stratum B2 - Above WT	21,24,22,2	23.467 ft²
Region 4	Stratum A (SC/SM)	6,7,8,9,10,11,12,13,14,5	209.88 ft²
Region 5	Stratum A (SC/SM)	15,16,36,35,14	390.23 ft²
Region 6	Stratum B2 - Above WT	20,19,29,28,4	1,010 ft²
Region 7	Stratum B1 Undrained	19,18,30,29	959.5 ft²
Region 8	Stratum B2 - Above WT	18,3,23,17,31,30	601.46 ft²
Region 9	Stratum C1 Undrained	26,25,32,33	4,255 ft²

Region 10	Stratum C1 Undrained	27,26,33,34	4,600 ft ²
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Current Slip Surface

Slip Surface: 289

Factor of Safety: 1.5

Volume: 7,056.0739 ft³

Weight: 857,043.25 lbf

Resisting Moment: 20,578,083 lbf-ft

Activating Moment: 13,633,201 lbf-ft

Resisting Force: 170,934.08 lbf

Activating Force: 114,201.33 lbf

Slip Rank: 1 of 4,805 slip surfaces

Exit: (64.632664, 24.27166) ft

Entry: (-106.61536, 51.529921) ft

Radius: 96.887269 ft

Center: (-14.193823, 80.605735) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-106.1982 ft	50.26496 ft	-1,670.1335 psf	-1,841.2196 psf	-0 psf	1,000 psf
Slice 2	-104.63313 ft	46 ft	-1,404 psf	292.8744 psf	205.07286 psf	50 psf
Slice 3	-101.7426 ft	39.305963 ft	-986.29207 psf	227.20626 psf	0 psf	1,000 psf
Slice 4	-99.429501 ft	34.555963 ft	-689.89207 psf	1,016.8923 psf	0 psf	1,000 psf
Slice 5	-95.661046 ft	28.5 ft	-312 psf	1,711.632 psf	1,198.4977 psf	50 psf
Slice 6	-90.51051 ft	21 ft	156 psf	2,540.5664 psf	1,669.6913 psf	0 psf
Slice 7	-84.528966 ft	14.230658 ft	578.40692 psf	4,066.4911 psf	0 psf	1,000 psf
Slice 8	-78.021846 ft	7.7890715 ft	980.36194 psf	5,222.3784 psf	0 psf	1,000 psf
Slice 9	-73.065539 ft	3.7193111 ft	1,234.315 psf	5,797.6512 psf	0 psf	1,000 psf
Slice 10	-68.109232 ft	0.16089796 ft	1,456.36 psf	6,308.333 psf	0 psf	1,000 psf
Slice 11	-65.315539 ft	-1.6959972 ft	1,572.2302 psf	6,578.1014 psf	0 psf	1,000 psf
Slice 12	-62.583333 ft	-3.2859503 ft	1,671.4433 psf	6,814.5857 psf	0 psf	1,000 psf
Slice 13	-57.75 ft	-5.8967587 ft	1,834.3577 psf	7,210.1464 psf	0 psf	1,000 psf

Slice 14	-52.916667 ft	-8.1677568 ft	1,976.068 psf	7,567.8003 psf	0 psf	1,000 psf
Slice 15	-47.625 ft	-10.279442 ft	2,107.8372 psf	7,672.6753 psf	0 psf	1,000 psf
Slice 16	-41.875 ft	-12.194558 ft	2,227.3404 psf	8,016.7835 psf	0 psf	1,000 psf
Slice 17	-38 ft	-13.305631 ft	2,296.6714 psf	8,162.6278 psf	0 psf	1,000 psf
Slice 18	-36.333335 ft	-13.71561 ft	2,322.254 psf	8,134.9619 psf	0 psf	1,000 psf
Slice 19	-32.54167 ft	-14.475126 ft	2,369.6479 psf	8,059.2892 psf	0 psf	1,000 psf
Slice 20	-26.29167 ft	-15.471654 ft	2,431.8312 psf	7,906.8923 psf	0 psf	1,000 psf
Slice 21	-21.083335 ft	-16.0137 ft	2,465.6549 psf	7,739.7808 psf	0 psf	1,000 psf
Slice 22	-16.5 ft	-16.221797 ft	2,478.6401 psf	4,815.6694 psf	0 psf	1,000 psf
Slice 23	-9.75 ft	-16.086016 ft	2,470.1674 psf	5,120.161 psf	0 psf	1,000 psf
Slice 24	-2.75 ft	-15.563451 ft	2,437.5593 psf	5,379.8982 psf	0 psf	1,000 psf
Slice 25	2.75 ft	-14.747548 ft	2,386.647 psf	5,342.8667 psf	0 psf	1,000 psf
Slice 26	7.5 ft	-13.799296 ft	2,327.4761 psf	5,248.5275 psf	0 psf	1,000 psf
Slice 27	12 ft	-12.637406 ft	2,254.9742 psf	5,153.2943 psf	0 psf	1,000 psf
Slice 28	16.875 ft	-11.130755 ft	2,160.9591 psf	5,047.6804 psf	0 psf	1,000 psf
Slice 29	21.625 ft	-9.3810451 ft	2,051.7772 psf	4,878.3216 psf	0 psf	1,000 psf
Slice 30	24.75 ft	-8.1064443 ft	1,972.2421 psf	4,720.2576 psf	0 psf	1,000 psf
Slice 31	26.5 ft	-7.3143511 ft	1,922.8155 psf	4,638.8745 psf	0 psf	1,000 psf
Slice 32	31.75 ft	-4.5587465 ft	1,750.8658 psf	4,378.0871 psf	0 psf	1,000 psf
Slice 33	36.621716 ft	-1.882996 ft	1,583.899 psf	4,072.7737 psf	0 psf	1,000 psf
Slice 34	40.682575 ft	0.86682071 ft	1,412.3104 psf	3,642.144 psf	0 psf	1,000 psf
Slice 35	47.560858 ft	6.0835736 ft	1,086.785 psf	2,853.4318 psf	0 psf	1,000 psf
Slice 36	53.292571 ft	11.161441 ft	769.92609 psf	2,213.6849 psf	0 psf	1,000 psf
Slice 37	57.877714 ft	15.944688 ft	471.45147 psf	1,742.1286 psf	0 psf	1,000 psf

Slice 38	62.122864 ft	21 ft	156 psf	739.91934 psf	408.86472 psf	0 psf
Slice 39	64.354053 ft	23.88583 ft	-24.075799 psf	192.33834 psf	111.04659 psf	50 psf

8267+50, Long Term

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File Information

File Version: 9.00
Created By: [Fernanda Madrona](#)
Last Edited By: [Garden, Alistair S](#)
Revision Number: 89
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Time: 04:33:38 PM
Tool Version: 9.0.3.15488
File Name: [SECTION E-E' \(BH-03\).gsz](#)
Directory: [C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\](#)
Last Solved Date: 05/28/2020
Last Solved Time: 04:33:50 PM

Project Settings

Unit System: [U.S. Customary Units](#)

Analysis Settings

8267+50, Long Term

Kind: [SLOPE/W](#)
Method: [Morgenstern-Price](#)
Settings
Side Function
Interslice force function option: [Half-Sine](#)
PWP Conditions from: [Piezometric Line](#)
Apply Phreatic Correction: [No](#)
Use Staged Rapid Drawdown: [No](#)
Unit Weight of Water: [62.4 pcf](#)
Slip Surface
Direction of movement: [Left to Right](#)
Use Passive Mode: [No](#)
Slip Surface Option: [Entry and Exit](#)
Critical slip surfaces saved: [1](#)
Optimize Critical Slip Surface Location: [No](#)
Tension Crack Option: [\(none\)](#)
Distribution
F of S Calculation Option: [Constant](#)
Advanced
Geometry Settings
Minimum Slip Surface Depth: [0.1 ft](#)
Number of Slices: [30](#)

Factor of Safety Convergence Settings
Maximum Number of Iterations: [100](#)
Tolerable difference in F of S: [0.001](#)

Solution Settings
Search Method: [Linear Search](#)
Must Obtain at Lambda Factor of Safety: [0.2](#)
Lambda
Lambda 1: [-1](#)
Lambda 2: [-0.8](#)
Lambda 3: [-0.6](#)
Lambda 4: [-0.4](#)
Lambda 5: [-0.2](#)
Lambda 6: [0](#)
Lambda 7: [0.2](#)
Lambda 8: [0.4](#)
Lambda 9: [0.6](#)
Lambda 10: [0.8](#)
Lambda 11: [1](#)

Materials

Stratum A (SC/SM)

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [30 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Drained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [26 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Drained - Residual

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi': [13 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Drained - Fully Softened

Model: [Spatial Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi Fn: [Fully Softened](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-109.5, 50.88889\) ft](#)
Left-Zone Right Coordinate: [\(-22.94181, 48.89207\) ft](#)
Left-Zone Increment: [30](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-17.5, 23.5\) ft](#)
Right-Zone Right Coordinate: [\(77.5, 25\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-120, 48.625\) ft](#)
Right Coordinate: [\(110, 41.42857\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-120 ft	23.5 ft
Coordinate 2	110 ft	23.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 45\) ft](#)
Inside Point: [\(-48.9437, 36.97661\) ft](#)
Length: [30.999999 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252.8 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [196.78936 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)
Required Length: [0 ft](#)
Governing Component: [\(none\)](#)

Reinforcement 2

Type: [Nail](#)
Outside Point: [\(-19, 41\) ft](#)
Inside Point: [\(-48.9437, 32.97661\) ft](#)
Length: [30.999999 ft](#)
Direction: [15 °](#)
F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,252.8 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)

Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 196.78936 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 3

Type: Nail
 Outside Point: (-19, 37) ft
 Inside Point: (-48.9437, 28.97661) ft
 Length: 30.999999 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,252.8 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 196.78936 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 4

Type: Nail
 Outside Point: (-19, 33) ft
 Inside Point: (-48.9437, 24.97661) ft
 Length: 30.999999 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf

Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 5

Type: Nail
 Outside Point: (-19, 29) ft
 Inside Point: (-48.9437, 20.97661) ft
 Length: 30.999999 ft
 Direction: 15 °
 F of S Dependent: Yes
 Force Distribution: Distributed
 Anchorage: Yes
 Pullout Resistance: 1,872 psf
 Resistance Reduction Factor: 2
 Bond Diameter: 0.5 ft
 Nail Spacing: 5 ft
 Tensile Capacity: 47,400 lbf
 Reduction Factor: 1.8
 Shear Force: 0 lbf
 Shear Reduction Factor: 1
 Apply Shear: Parallel to Slip
 Factored Pullout Resistance: 294.05307 lbf/ft
 Max. Pullout Force: 5,266.6667 lbf
 Factored Tensile Capacity: 5,266.6667 lbf
 Pullout Force: 0 lbf
 Pullout Force per Length: 0 lbf/ft
 Available Length: 0 ft
 Required Length: 0 ft
 Governing Component: (none)

Reinforcement 6

Type: Nail
 Outside Point: (-19, 25) ft
 Inside Point: (-48.9437, 16.97661) ft
 Length: 30.999999 ft
 Direction: 15 °

F of S Dependent: [Yes](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [9,115.645 lbf](#)
Factored Tensile Capacity: [9,480 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)
Required Length: [0 ft](#)
Governing Component: [\(none\)](#)

Surcharge Loads

Surcharge Load 1
Surcharge (Unit Weight): [250 pcf](#)
Direction: [Vertical](#)

Coordinates

	X	Y
	-80.5 ft	55.15 ft
	-50.5 ft	56.9 ft

Phi Functions

Fully Softened
Model: [Spline Data Point Function](#)
Function: [Phi vs. Y](#)
Curve Fit to Data: [100 %](#)
Segment Curvature: [100 %](#)
Y-Intercept: [23.461538](#)
Data Points: [Y \(ft\), Phi \(°\)](#)
Data Point: [\(-1.5, 23\)](#)
Data Point: [\(18, 29\)](#)



	X	Y
Point 1	-100 ft	53 ft
Point 2	-65 ft	55 ft
Point 3	-19 ft	47 ft
Point 4	-19 ft	23.5 ft
Point 5	-14 ft	23.5 ft
Point 6	-5.5 ft	27.5 ft
Point 7	5.5 ft	27.5 ft
Point 8	9.5 ft	27 ft
Point 9	14.5 ft	27.5 ft
Point 10	24 ft	27.5 ft
Point 11	25.5 ft	27 ft
Point 12	27.5 ft	27.5 ft
Point 13	36 ft	27.5 ft
Point 14	51 ft	23.5 ft
Point 15	77.5 ft	25 ft
Point 16	102.5 ft	41 ft
Point 17	-118 ft	49 ft
Point 18	-19 ft	43 ft
Point 19	-19 ft	33.5 ft
Point 20	-19 ft	29.4 ft
Point 21	-37 ft	55 ft
Point 22	-39 ft	56.6 ft
Point 23	-23.16667 ft	49 ft
		55 ft

Point 24	-35.66667 ft	
Point 25	-120 ft	-20 ft
Point 26	-120 ft	-1.5 ft
Point 27	-120 ft	18.5 ft
Point 28	-120 ft	23.5 ft
Point 29	-120 ft	33.5 ft
Point 30	-120 ft	43 ft
Point 31	-120 ft	48.625 ft
Point 32	110 ft	-20 ft
Point 33	110 ft	-1.5 ft
Point 34	110 ft	18.5 ft
Point 35	110 ft	23.5 ft
Point 36	110 ft	41.42857 ft

Regions

	Material	Points	Area
Region 1	Stratum B1 Drained	2,1,17,23,24,21	424.5 ft²
Region 2	Stratum B2 - Below WT	4,28,27,34,35,14,5	1,150 ft²
Region 3	Stratum B2 - Above WT	21,24,22,2	23.467 ft²
Region 4	Stratum A (SC/SM)	6,7,8,9,10,11,12,13,14,5	209.88 ft²
Region 5	Stratum A (SC/SM)	15,16,36,35,14	390.23 ft²
Region 6	Stratum B2 - Above WT	20,19,29,28,4	1,010 ft²
Region 7	Stratum B1 Drained	19,18,30,29	959.5 ft²
Region 8	Stratum B2 - Above WT	18,3,23,17,31,30	601.46 ft²
Region 9	Stratum C1 Drained - Residual	26,25,32,33	4,255 ft²
Region 10	Stratum C1 Drained - Fully Softened	27,26,33,34	4,600 ft²

Current Slip Surface

Slip Surface: 924
Factor of Safety: 1.5
Volume: 6,361.0806 ft³

Weight: 772,536.85 lbf
Resisting Moment: 19,274,312 lbf-ft
Activating Moment: 13,220,544 lbf-ft
Resisting Force: 160,855.21 lbf
Activating Force: 111,527.33 lbf
Slip Rank: 1 of 4,805 slip surfaces
Exit: (74.283166, 24.817915) ft
Entry: (-94.964903, 53.28772) ft
Radius: 96.279453 ft
Center: (-3.0990313, 82.104289) ft

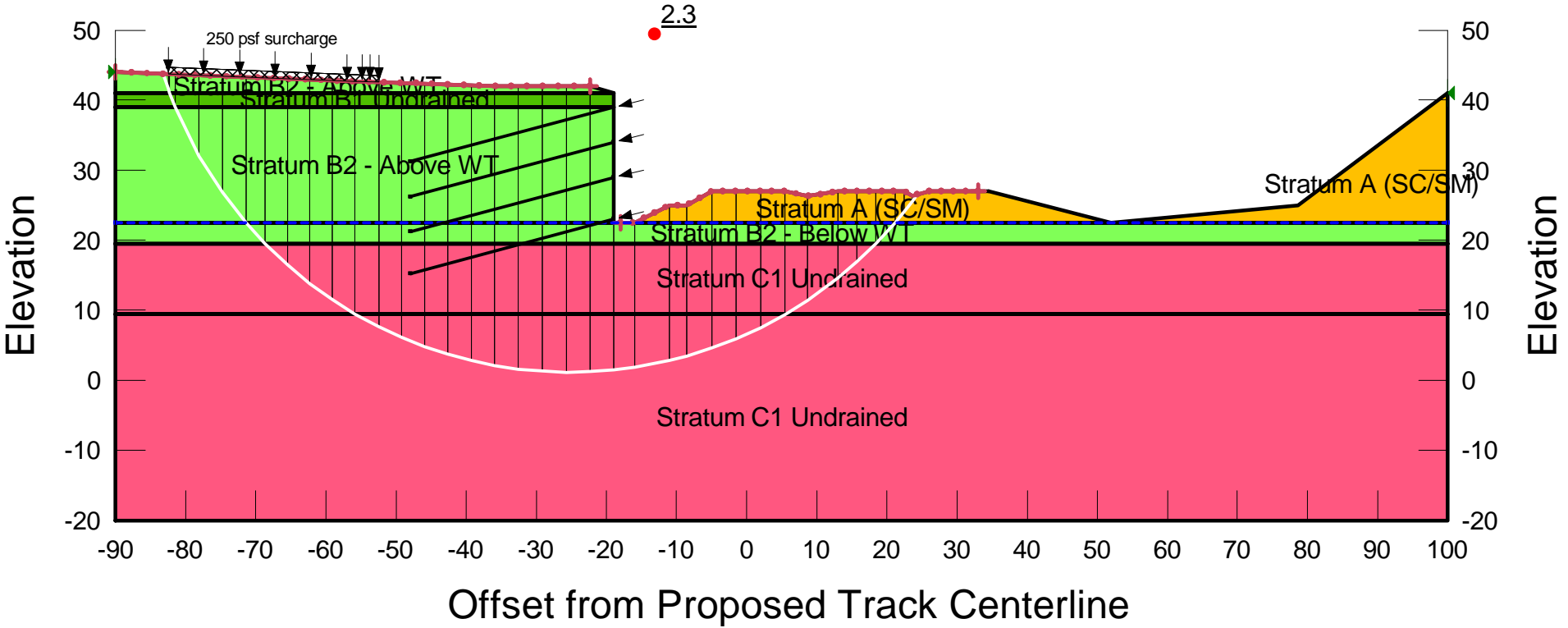
Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-94.236611 ft	51.14386 ft	-1,724.9769 psf	81.008624 psf	39.510546 psf	50 psf
Slice 2	-92.293979 ft	46 ft	-1,404 psf	374.08624 psf	261.93801 psf	50 psf
Slice 3	-88.644589 ft	38.25 ft	-920.4 psf	1,079.0539 psf	526.28976 psf	50 psf
Slice 4	-83.354769 ft	29.17164 ft	-353.91034 psf	1,687.6723 psf	1,181.7208 psf	50 psf
Slice 5	-79.993986 ft	24.17164 ft	-41.910343 psf	2,324.9288 psf	1,627.9327 psf	50 psf
Slice 6	-77.432911 ft	21 ft	156 psf	2,738.7641 psf	1,808.4709 psf	0 psf
Slice 7	-72.783387 ft	15.774332 ft	482.08167 psf	3,643.5065 psf	1,703.3324 psf	0 psf
Slice 8	-67.594462 ft	10.705068 ft	798.40377 psf	4,363.55 psf	1,797.4035 psf	0 psf
Slice 9	-62.641494 ft	6.5039238 ft	1,060.5552 psf	4,979.274 psf	1,866.0063 psf	0 psf
Slice 10	-57.924481 ft	3.0115095 ft	1,278.4818 psf	5,508.9463 psf	1,917.9695 psf	0 psf
Slice 11	-53.207469 ft	-0.061678696 ft	1,470.2488 psf	5,993.53 psf	1,961.3891 psf	0 psf
Slice 12	-50.674481 ft	-1.5991719 ft	1,566.1883 psf	6,521.7754 psf	1,144.0874 psf	0 psf
Slice 13	-47.625 ft	-3.1990144 ft	1,666.0185 psf	6,536.4714 psf	1,124.4327 psf	0 psf
Slice 14	-41.875 ft	-5.9655095 ft	1,838.6478 psf	6,972.279 psf	1,185.1921 psf	0 psf
Slice 15	-38 ft	-7.6203128 ft	1,941.9075 psf	7,187.2871 psf	1,210.9913 psf	0 psf
Slice 16	-36.333335 ft	-8.2544935 ft	1,981.4804 psf	7,194.6317 psf	1,203.5508 psf	0 psf
Slice 17	-32.54167 ft	-9.5040607 ft	2,059.4534 psf	7,197.2781 psf	1,186.1603 psf	0 psf

Slice 18	-26.29167 ft	-11.284504 ft	2,170.5531 psf	7,173.1281 psf	1,154.9355 psf	0 psf
Slice 19	-21.083335 ft	-12.456806 ft	2,243.7047 psf	7,111.9558 psf	1,123.9243 psf	0 psf
Slice 20	-16.5 ft	-13.204544 ft	2,290.3635 psf	4,332.1295 psf	471.37881 psf	0 psf
Slice 21	-11.875 ft	-13.750612 ft	2,324.4382 psf	4,570.4511 psf	518.53294 psf	0 psf
Slice 22	-7.625 ft	-14.045194 ft	2,342.8201 psf	4,899.1041 psf	590.16467 psf	0 psf
Slice 23	-2.75 ft	-14.135249 ft	2,348.4395 psf	5,095.9672 psf	634.31673 psf	0 psf
Slice 24	2.75 ft	-13.957834 ft	2,337.3688 psf	5,147.8962 psf	648.86138 psf	0 psf
Slice 25	7.5 ft	-13.568824 ft	2,313.0946 psf	5,130.6359 psf	650.48066 psf	0 psf
Slice 26	12 ft	-12.950141 ft	2,274.4888 psf	5,109.4022 psf	654.49133 psf	0 psf
Slice 27	16.875 ft	-12.049185 ft	2,218.2692 psf	5,084.9771 psf	661.83167 psf	0 psf
Slice 28	21.625 ft	-10.914076 ft	2,147.4383 psf	4,992.0944 psf	656.7406 psf	0 psf
Slice 29	24.75 ft	-10.056173 ft	2,093.9052 psf	4,880.8215 psf	643.41032 psf	0 psf
Slice 30	26.5 ft	-9.5064421 ft	2,059.602 psf	4,826.3279 psf	638.749 psf	0 psf
Slice 31	29.625 ft	-8.4151293 ft	1,991.5041 psf	4,745.2352 psf	635.74893 psf	0 psf
Slice 32	33.875 ft	-6.7627847 ft	1,888.3978 psf	4,563.2662 psf	617.54204 psf	0 psf
Slice 33	38.162725 ft	-4.8524245 ft	1,769.1913 psf	4,263.8119 psf	575.92855 psf	0 psf
Slice 34	42.488175 ft	-2.6630958 ft	1,632.5772 psf	3,841.6449 psf	510.00347 psf	0 psf
Slice 35	47.82545 ft	0.48058029 ft	1,436.4118 psf	3,468.2937 psf	888.10477 psf	0 psf
Slice 36	54.029964 ft	4.6973799 ft	1,173.2835 psf	2,842.6154 psf	775.12194 psf	0 psf
Slice 37	60.089893 ft	9.5733012 ft	869.026 psf	2,272.0062 psf	696.66424 psf	0 psf
Slice 38	66.149822 ft	15.356502 ft	508.1543 psf	1,548.9429 psf	557.75296 psf	0 psf
Slice 39	71.234848 ft	21 ft	156 psf	894.8416 psf	517.34245 psf	0 psf
Slice 40	73.786538 ft	24.158958 ft	-41.11895 psf	257.29591 psf	148.54986 psf	50 psf

Arkendale to Powells Creek Third Track Project
Soil Nail Wall - Global Stability Analysis
Station 8268+50 Short Term
Section F-F'

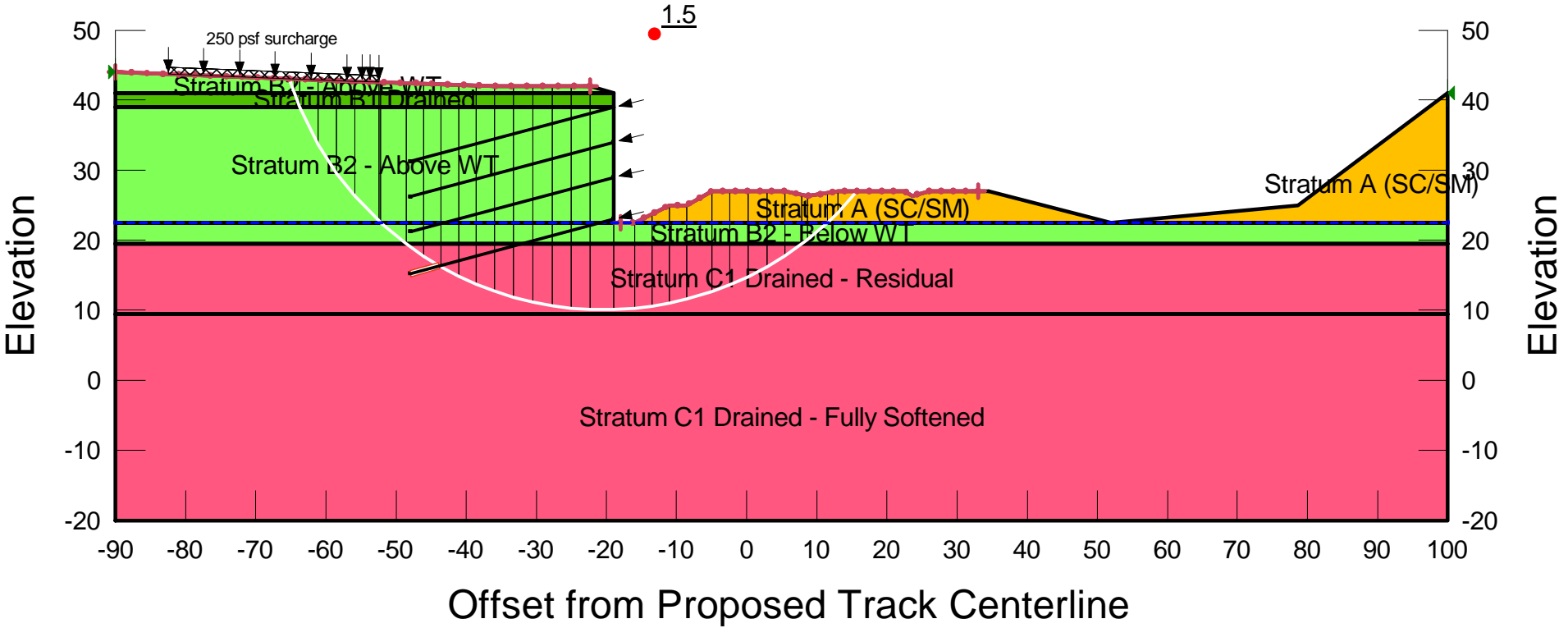
			(pcf)	(psf)	(°)
<div></div>	Stratum A (SC/SM)	Mohr-Coulomb	120	50	30
<div></div>	Stratum B1 Undrained	Mohr-Coulomb	120	1,000	0
<div></div>	Stratum B2 - Above WT	Mohr-Coulomb	125	50	35
<div></div>	Stratum B2 - Below WT	Mohr-Coulomb	125	0	35
<div></div>	Stratum C1 Undrained	Mohr-Coulomb	120	1,000	0



Units for Offset and Elevation are in feet.

Arkendale to Powells Creek Third Track Project
 Soil Nail Wall - Global Stability Analysis
 Station 8268+50 Long Term
 Section F-F'

			(pcf)	(psf)	(°)
<div></div>	Stratum A (SC/SM)	Mohr-Coulomb	120	50	30
<div></div>	Stratum B1 Drained	Mohr-Coulomb	120	50	26
<div></div>	Stratum B2 - Above WT	Mohr-Coulomb	125	50	35
<div></div>	Stratum B2 - Below WT	Mohr-Coulomb	125	0	35
<div></div>	Stratum C1 Drained - Fully Softened	Mohr-Coulomb	120	0	23
<div></div>	Stratum C1 Drained - Residual	Mohr-Coulomb	120	0	13



Units for Offset and Elevation are in feet.

8268+50 Short Term

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File Version: 9.00
Created By: Max Showalter
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Revision Number: 40
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Tool Version: 9.0.3.15488
File Name: SECTION F-F' (BH-04).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 05/29/2020
Last Solved Time: 10:24:40 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8268+50 Short Term

Kind: [SLOPE/W](#)
Method: [Morgenstern-Price](#)
Settings
Side Function
Interslice force function option: [Half-Sine](#)
PWP Conditions from: [Piezometric Line](#)
Apply Phreatic Correction: [No](#)
Use Staged Rapid Drawdown: [No](#)
Unit Weight of Water: [62.4 pcf](#)
Slip Surface
Direction of movement: [Left to Right](#)
Use Passive Mode: [No](#)
Slip Surface Option: [Entry and Exit](#)
Critical slip surfaces saved: [1](#)
Optimize Critical Slip Surface Location: [No](#)
Tension Crack Option: [\(none\)](#)
Distribution
F of S Calculation Option: [Constant](#)
Advanced
Geometry Settings
Minimum Slip Surface Depth: [0.1 ft](#)
Number of Slices: [30](#)

Factor of Safety Convergence Settings
Maximum Number of Iterations: [100](#)
Tolerable difference in F of S: [0.001](#)

Solution Settings
Search Method: [Linear Search](#)
Must Obtain at Lambda Factor of Safety: [0.2](#)
Lambda
Lambda 1: [-1](#)
Lambda 2: [-0.8](#)
Lambda 3: [-0.6](#)
Lambda 4: [-0.4](#)
Lambda 5: [-0.2](#)
Lambda 6: [0](#)
Lambda 7: [0.2](#)
Lambda 8: [0.4](#)
Lambda 9: [0.6](#)
Lambda 10: [0.8](#)
Lambda 11: [1](#)

Materials

Stratum A (SC/SM)

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [50 psf](#)
Phi': [30 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Above WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [50 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Undrained

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [1,000 psf](#)
Phi': [0 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-90, 44.05\) ft](#)
Left-Zone Right Coordinate: [\(-22.3001, 42\) ft](#)
Left-Zone Increment: [30](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-18, 22.5\) ft](#)
Right-Zone Right Coordinate: [\(33.00691, 27\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-90, 44.05\) ft](#)
Right Coordinate: [\(100, 41\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-90 ft	22.5 ft
Coordinate 2	100 ft	22.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 29\) ft](#)
Inside Point: [\(-47.97778, 21.23544\) ft](#)
Length: [30.000002 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)
Required Length: [0 ft](#)
Governing Component: [\(none\)](#)

Reinforcement 2

Type: [Nail](#)
Outside Point: [\(-19, 34\) ft](#)
Inside Point: [\(-47.97778, 26.23544\) ft](#)
Length: [30.000002 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)

Required Length: 0 ft
Governing Component: (none)

Reinforcement 3

Type: Nail
Outside Point: (-19, 39) ft
Inside Point: (-47.97778, 31.23544) ft
Length: 30.000002 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 4

Type: Nail
Outside Point: (-19, 23) ft
Inside Point: (-47.97778, 15.23544) ft
Length: 30.000002 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,252 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 196.6637 lbf/ft
Max. Pullout Force: 5,266.6667 lbf

Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-82.5 ft	44.7 ft
	-52.5 ft	43.5 ft

Points

	X	Y
Point 1	-90 ft	44.05 ft
Point 2	-55.88335 ft	42.7 ft
Point 3	-36 ft	42 ft
Point 4	-19 ft	22.5 ft
Point 5	-16 ft	22.5 ft
Point 6	-11 ft	25 ft
Point 7	-8.5 ft	25 ft
Point 8	-5 ft	27 ft
Point 9	5.5 ft	27 ft
Point 10	8.7 ft	26.3 ft
Point 11	13 ft	27 ft
Point 12	22.5 ft	27 ft
Point 13	23.65 ft	26.35 ft
Point 14	26 ft	27 ft
Point 15	34.5 ft	27 ft
Point 16	52 ft	22.5 ft
Point 17	78.65 ft	25 ft
Point 18	100 ft	41 ft
Point 19	-90 ft	-20 ft
Point 20	100 ft	-20 ft
Point 21	-90 ft	41 ft
Point 22	-90 ft	39 ft
Point 23	-90 ft	19.5 ft

Point 24	100 ft	19.5 ft
Point 25	-19 ft	41 ft
Point 26	-22.3001 ft	42 ft
Point 27	-19 ft	39 ft
Point 28	-90 ft	9.5 ft
Point 29	100 ft	9.5 ft
Point 30	100 ft	22.5 ft
Point 31	-90 ft	22.5 ft

Regions

	Material	Points	Area
Region 1	Stratum B2 - Above WT	3,2,1,21,25,26	123.22 ft²
Region 2	Stratum B1 Undrained	21,22,27,25	142 ft²
Region 3	Stratum A (SC/SM)	18,17,16,30	257.49 ft²
Region 4	Stratum C1 Undrained	23,28,29,24	1,900 ft²
Region 5	Stratum B2 - Below WT	4,31,23,24,30,16,5	570 ft²
Region 6	Stratum A (SC/SM)	15,14,13,12,11,10,9,8,7,6,5,16	238.11 ft²
Region 7	Stratum B2 - Above WT	27,22,31,4	1,171.5 ft²
Region 8	Stratum C1 Undrained	19,20,29,28	5,605 ft²

Current Slip Surface

Slip Surface: 594
Factor of Safety: 2.3
Volume: 2,701.8787 ft³
Weight: 330,869.7 lbf
Resisting Moment: 7,747,281 lbf-ft
Activating Moment: 3,296,624.8 lbf-ft
Resisting Force: 104,348.92 lbf
Activating Force: 44,883.358 lbf
Slip Rank: 1 of 4,805 slip surfaces
Exit: (24.316826, 26.534441) ft
Entry: (-83.231405, 43.782166) ft
Radius: 60.891264 ft
Center: (-25.14474, 62.049221) ft

Slip Slices

	X	Y	PWP			
--	---	---	-----	--	--	--

				Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-82.865703 ft	42.6917 ft	-1,259.9621 psf	37.547218 psf	26.290845 psf	50 psf
Slice 2	-82.391043 ft	41.300617 ft	-1,173.1585 psf	264.67436 psf	185.32699 psf	50 psf
Slice 3	-81.893545 ft	40 ft	-1,092 psf	-390.98421 psf	-0 psf	1,000 psf
Slice 4	-79.828141 ft	35.540844 ft	-813.74869 psf	731.44642 psf	512.1643 psf	50 psf
Slice 5	-76.474414 ft	29.442002 ft	-433.1809 psf	1,297.3979 psf	908.44778 psf	50 psf
Slice 6	-73.120687 ft	24.651157 ft	-134.23221 psf	1,781.7197 psf	1,247.5736 psf	50 psf
Slice 7	-70.073342 ft	21 ft	93.6 psf	2,212.1505 psf	1,483.4251 psf	0 psf
Slice 8	-67.103395 ft	17.977233 ft	282.22069 psf	2,807.6327 psf	0 psf	1,000 psf
Slice 9	-63.904466 ft	15.133069 ft	459.69648 psf	3,159.1208 psf	0 psf	1,000 psf
Slice 10	-60.705536 ft	12.66004 ft	614.01352 psf	3,465.6109 psf	0 psf	1,000 psf
Slice 11	-57.494711 ft	10.497243 ft	748.97206 psf	3,737.4423 psf	0 psf	1,000 psf
Slice 12	-54.191675 ft	8.5673019 ft	869.40036 psf	3,985.2864 psf	0 psf	1,000 psf
Slice 13	-50.85 ft	6.8797358 ft	974.70449 psf	3,989.1755 psf	0 psf	1,000 psf
Slice 14	-47.55 ft	5.4576924 ft	1,063.44 psf	4,190.1386 psf	0 psf	1,000 psf
Slice 15	-44.25 ft	4.2589535 ft	1,138.2413 psf	4,369.7778 psf	0 psf	1,000 psf
Slice 16	-40.95 ft	3.269799 ft	1,199.9645 psf	4,529.3161 psf	0 psf	1,000 psf
Slice 17	-37.65 ft	2.4797487 ft	1,249.2637 psf	4,669.2871 psf	0 psf	1,000 psf
Slice 18	-34.287512 ft	1.8731839 ft	1,287.1133 psf	4,798.975 psf	0 psf	1,000 psf
Slice 19	-30.862537 ft	1.4514149 ft	1,313.4317 psf	4,917.2424 psf	0 psf	1,000 psf
Slice 20	-27.437562 ft	1.2252765 ft	1,327.5427 psf	5,013.0367 psf	0 psf	1,000 psf
Slice 21	-24.012587 ft	1.1925809 ft	1,329.583 psf	5,085.0115 psf	0 psf	1,000 psf
Slice 22	-20.65005 ft	1.3466163 ft	1,319.9711 psf	5,068.2223 psf	0 psf	1,000 psf
Slice 23	-17.5 ft	1.6586759 ft	1,300.4986 psf	2,696.5548 psf	0 psf	1,000 psf

Slice 24	-13.5 ft	2.3360868 ft	1,258.2282 psf	2,822.3844 psf	0 psf	1,000 psf
Slice 25	-9.75 ft	3.1503349 ft	1,207.4191 psf	2,924.5094 psf	0 psf	1,000 psf
Slice 26	-6.75 ft	4.0319026 ft	1,152.4093 psf	2,974.1048 psf	0 psf	1,000 psf
Slice 27	-3.25 ft	5.26147 ft	1,075.6843 psf	2,982.2038 psf	0 psf	1,000 psf
Slice 28	0.25 ft	6.7396817 ft	983.44386 psf	2,831.0739 psf	0 psf	1,000 psf
Slice 29	3.75 ft	8.4872354 ft	874.39651 psf	2,641.86 psf	0 psf	1,000 psf
Slice 30	7.1 ft	10.430776 ft	753.11956 psf	2,381.0613 psf	0 psf	1,000 psf
Slice 31	10.85 ft	13.008299 ft	592.28214 psf	2,087.4458 psf	0 psf	1,000 psf
Slice 32	14.353345 ft	15.740654 ft	421.78317 psf	1,819.0875 psf	0 psf	1,000 psf
Slice 33	17.060035 ft	18.197483 ft	268.47705 psf	1,542.0601 psf	0 psf	1,000 psf
Slice 34	19.783862 ft	21 ft	93.6 psf	1,078.2701 psf	689.47345 psf	0 psf
Slice 35	21.827172 ft	23.31594 ft	-50.914631 psf	682.10255 psf	393.81209 psf	50 psf
Slice 36	23.075 ft	24.877784 ft	-148.37372 psf	361.83315 psf	208.90447 psf	50 psf
Slice 37	23.983413 ft	26.079065 ft	-223.33365 psf	109.86424 psf	63.430147 psf	50 psf

8268+50 Long Term

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File Information

File Version: 9.00
Created By: Max Showalter
Last Edited By: Garden, Alistair S
Revision Number: 40
Date: 05/29/2020
Time: 10:24:28 AM
Tool Version: 9.0.3.15488
File Name: SECTION F-F' (BH-04).gsz
Directory: C:\Users\asgarden\Desktop\WFH\Arkendale\Updated Runs\
Last Solved Date: 05/29/2020
Last Solved Time: 10:24:44 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

8268+50 Long Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Stratum A (SC/SM)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B2 - Above WT

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum B1 Drained

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Stratum C1 Drained - Residual

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi': [13 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum B2 - Below WT

Model: [Mohr-Coulomb](#)
Unit Weight: [125 pcf](#)
Cohesion': [0 psf](#)
Phi': [35 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Stratum C1 Drained - Fully Softened

Model: [Mohr-Coulomb](#)
Unit Weight: [120 pcf](#)
Cohesion': [0 psf](#)
Phi': [23 °](#)
Phi-B: [0 °](#)
Pore Water Pressure
Piezometric Line: [1](#)

Slip Surface Entry and Exit

Left Type: [Range](#)
Left-Zone Left Coordinate: [\(-90, 44.05\) ft](#)
Left-Zone Right Coordinate: [\(-22.3001, 42\) ft](#)
Left-Zone Increment: [30](#)
Right Type: [Range](#)
Right-Zone Left Coordinate: [\(-18, 22.5\) ft](#)
Right-Zone Right Coordinate: [\(33.00691, 27\) ft](#)
Right-Zone Increment: [30](#)
Radius Increments: [4](#)

Slip Surface Limits

Left Coordinate: [\(-90, 44.05\) ft](#)
Right Coordinate: [\(100, 41\) ft](#)

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-90 ft	22.5 ft
Coordinate 2	100 ft	22.5 ft

Reinforcements

Reinforcement 1

Type: [Nail](#)
Outside Point: [\(-19, 29\) ft](#)
Inside Point: [\(-47.97778, 21.23544\) ft](#)
Length: [30.000002 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)
Reduction Factor: [1.8](#)
Shear Force: [0 lbf](#)
Shear Reduction Factor: [1](#)
Apply Shear: [Parallel to Slip](#)
Factored Pullout Resistance: [294.05307 lbf/ft](#)
Max. Pullout Force: [5,266.6667 lbf](#)
Factored Tensile Capacity: [5,266.6667 lbf](#)
Pullout Force: [0 lbf](#)
Pullout Force per Length: [0 lbf/ft](#)
Available Length: [0 ft](#)
Required Length: [0 ft](#)
Governing Component: [\(none\)](#)

Reinforcement 2

Type: [Nail](#)
Outside Point: [\(-19, 34\) ft](#)
Inside Point: [\(-47.97778, 26.23544\) ft](#)
Length: [30.000002 ft](#)
Direction: [15 °](#)
F of S Dependent: [No](#)
Force Distribution: [Distributed](#)
Anchorage: [Yes](#)
Pullout Resistance: [1,872 psf](#)
Resistance Reduction Factor: [2](#)
Bond Diameter: [0.5 ft](#)
Nail Spacing: [5 ft](#)
Tensile Capacity: [47,400 lbf](#)

Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 3

Type: Nail
Outside Point: (-19, 39) ft
Inside Point: (-47.97778, 31.23544) ft
Length: 30.000002 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes
Pullout Resistance: 1,872 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 294.05307 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 4

Type: Nail
Outside Point: (-19, 23) ft
Inside Point: (-47.97778, 15.23544) ft
Slip Surface Intersection: (-43.827243, 16.347571) ft
Length: 30.000002 ft
Direction: 15 °
F of S Dependent: No
Force Distribution: Distributed
Anchorage: Yes

Pullout Resistance: 1,252 psf
Resistance Reduction Factor: 2
Bond Diameter: 0.5 ft
Nail Spacing: 5 ft
Tensile Capacity: 47,400 lbf
Reduction Factor: 1.8
Shear Force: 0 lbf
Shear Reduction Factor: 1
Apply Shear: Parallel to Slip
Factored Pullout Resistance: 196.6637 lbf/ft
Max. Pullout Force: 5,266.6667 lbf
Factored Tensile Capacity: 5,266.6667 lbf
Pullout Force: 845.05434 lbf
Pullout Force per Length: 196.6637 lbf/ft
Available Length: 4.2969513 ft
Required Length: 4.2969513 ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-82.5 ft	44.7 ft
	-52.5 ft	43.5 ft

Points

	X	Y
Point 1	-90 ft	44.05 ft
Point 2	-55.88335 ft	42.7 ft
Point 3	-36 ft	42 ft
Point 4	-19 ft	22.5 ft
Point 5	-16 ft	22.5 ft
Point 6	-11 ft	25 ft
Point 7	-8.5 ft	25 ft
Point 8	-5 ft	27 ft
Point 9	5.5 ft	27 ft
Point 10	8.7 ft	26.3 ft
Point 11	13 ft	27 ft
Point 12	22.5 ft	27 ft
Point 13	23.65 ft	26.35 ft

Point 14	26 ft	27 ft
Point 15	34.5 ft	27 ft
Point 16	52 ft	22.5 ft
Point 17	78.65 ft	25 ft
Point 18	100 ft	41 ft
Point 19	-90 ft	-20 ft
Point 20	100 ft	-20 ft
Point 21	-90 ft	41 ft
Point 22	-90 ft	39 ft
Point 23	-90 ft	19.5 ft
Point 24	100 ft	19.5 ft
Point 25	-19 ft	41 ft
Point 26	-22.3001 ft	42 ft
Point 27	-19 ft	39 ft
Point 28	-90 ft	9.5 ft
Point 29	100 ft	9.5 ft
Point 30	100 ft	22.5 ft
Point 31	-90 ft	22.5 ft

Regions

	Material	Points	Area
Region 1	Stratum B2 - Above WT	3,2,1,21,25,26	123.22 ft²
Region 2	Stratum B1 Drained	21,22,27,25	142 ft²
Region 3	Stratum A (SC/SM)	18,17,16,30	257.49 ft²
Region 4	Stratum C1 Drained - Residual	23,28,29,24	1,900 ft²
Region 5	Stratum B2 - Below WT	4,31,23,24,30,16,5	570 ft²
Region 6	Stratum A (SC/SM)	15,14,13,12,11,10,9,8,7,6,5,16	238.11 ft²
Region 7	Stratum B2 - Above WT	27,22,31,4	1,171.5 ft²

Region 8	Stratum C1 Drained - Fully Softened	19,20,29,28	5,605 ft²
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Current Slip Surface

Slip Surface: 1,809
Factor of Safety: 1.5
Volume: 1,455.3097 ft³
Weight: 179,116.46 lbf
Resisting Moment: 2,597,302.5 lbf-ft
Activating Moment: 1,763,206.6 lbf-ft
Resisting Force: 44,214.254 lbf
Activating Force: 30,201.276 lbf
Slip Rank: 1 of 4,805 slip surfaces
Exit: (15.759564, 27) ft
Entry: (-65.181819, 43.067942) ft
Radius: 46.939121 ft
Center: (-20.353455, 56.985512) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength
Slice 1	-64.834266 ft	42.033971 ft	-1,218.9198 psf	107.96761 psf	75.599735 psf	50 psf
Slice 2	-64.098428 ft	40 ft	-1,092 psf	278.58101 psf	135.87304 psf	50 psf
Slice 3	-62.405677 ft	36.342634 ft	-863.78039 psf	491.47625 psf	344.13537 psf	50 psf
Slice 4	-59.796746 ft	31.654099 ft	-571.21575 psf	882.6777 psf	618.05758 psf	50 psf
Slice 5	-57.187815 ft	27.967112 ft	-341.14776 psf	1,231.136 psf	862.05073 psf	50 psf
Slice 6	-54.191675 ft	24.546644 ft	-127.71059 psf	1,588.7968 psf	1,112.4875 psf	50 psf
Slice 7	-52.34865 ft	22.640997 ft	-8.7981948 psf	1,646.6486 psf	1,152.9958 psf	50 psf
Slice 8	-50.400864 ft	21 ft	93.6 psf	1,884.7698 psf	1,254.1906 psf	0 psf
Slice 9	-47.343985 ft	18.613418 ft	242.52273 psf	2,557.9997 psf	534.56999 psf	0 psf
Slice 10	-44.823099 ft	16.956333 ft	345.92482 psf	2,772.0121 psf	560.10637 psf	0 psf
Slice 11	-42.302214 ft	15.518667 ft	435.63517 psf	2,957.2655 psf	582.16424 psf	0 psf
Slice 12	-39.781328 ft	14.27812 ft	513.0453 psf	3,125.8521 psf	603.21398 psf	0 psf
Slice 13	-37.260443 ft	13.217841 ft	579.20673 psf	3,279.5493 psf	623.42321 psf	0 psf

Slice 14	-34.63001 ft	12.293313 ft	636.89726 psf	3,429.5543 psf	644.73568 psf	0 psf
Slice 15	-31.89003 ft	11.508146 ft	685.8917 psf	3,577.3733 psf	667.55113 psf	0 psf
Slice 16	-29.15005 ft	10.899118 ft	723.89504 psf	3,709.7353 psf	689.33555 psf	0 psf
Slice 17	-26.41007 ft	10.459285 ft	751.34061 psf	3,826.0278 psf	709.84748 psf	0 psf
Slice 18	-23.67009 ft	10.183859 ft	768.52718 psf	3,925.148 psf	728.76335 psf	0 psf
Slice 19	-20.65005 ft	10.076341 ft	775.23632 psf	3,946.1681 psf	732.06728 psf	0 psf
Slice 20	-17.5 ft	10.15731 ft	770.18386 psf	1,558.3463 psf	181.96164 psf	0 psf
Slice 21	-14.75 ft	10.399063 ft	755.09848 psf	1,634.659 psf	203.06255 psf	0 psf
Slice 22	-12.25 ft	10.768583 ft	732.04044 psf	1,772.0669 psf	240.10903 psf	0 psf
Slice 23	-9.75 ft	11.277731 ft	700.26957 psf	1,812.2152 psf	256.71288 psf	0 psf
Slice 24	-6.75 ft	12.09806 ft	649.08103 psf	1,863.8633 psf	280.45459 psf	0 psf
Slice 25	-3.6875 ft	13.127153 ft	584.86562 psf	1,886.3332 psf	300.46747 psf	0 psf
Slice 26	-1.0625 ft	14.217919 ft	516.80183 psf	1,759.818 psf	286.97289 psf	0 psf
Slice 27	1.5625 ft	15.503365 ft	436.59001 psf	1,602.4768 psf	269.16617 psf	0 psf
Slice 28	4.1875 ft	17.002378 ft	343.05159 psf	1,412.1769 psf	246.82702 psf	0 psf
Slice 29	6.6987589 ft	18.653984 ft	239.99139 psf	1,161.1481 psf	212.66578 psf	0 psf
Slice 30	8.2987589 ft	19.809241 ft	167.90333 psf	1,295.5674 psf	789.59889 psf	0 psf
Slice 31	10.095196 ft	21.309241 ft	74.303331 psf	1,107.0159 psf	723.11315 psf	0 psf
Slice 32	12.245196 ft	23.228912 ft	-45.484137 psf	800.89647 psf	462.39779 psf	50 psf
Slice 33	14.379782 ft	25.478912 ft	-185.88414 psf	400.1516 psf	231.02764 psf	50 psf

Appendix D

Lateral Capacity Analysis

Lateral Capacity Calculations (80 pages)



Lateral Load Distribution from Earth Pressure

Project Number:	JD205150	Project Engineer:	DK
Project Name:	Arkendale to Powells Creek, 3rd Track	Principal Engineer:	SU
Project Location:	Prince William County, Virginia	Date:	6/9/2020
Structure:	Retaining Wall No. 13 - Station 8263+00		

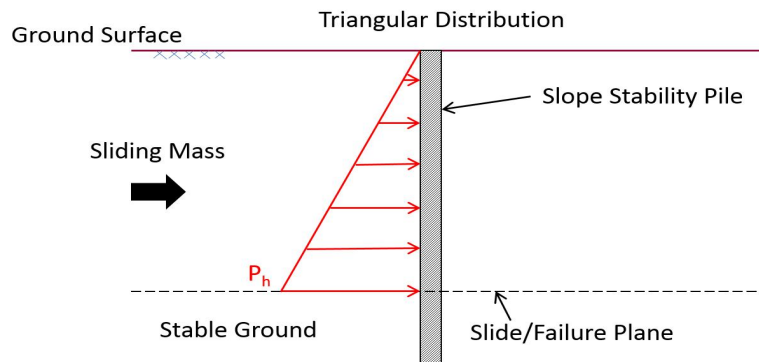
The Slope/W program calculated the *horizontal earth pressure* resultant load for the given pile spacing as shown in slope stability section of the report; however, for proper structural analysis of pile reaction, we converted this to a more realistic distributed load. For this purpose, we used triangular distribution for the approximation of the actual condition to develop a realistic calculation of distributed shear, moment, and displacement in the pile. Utilizing these known factors, we calculated a triangular distribution of loading from zero (0) at the top of the pile to a maximum at the depth of the shear surface from global stability analysis.

Input Values:

Shear Force Required from Piles to achieve the desired FOS =	2,200	lb/ft	for FOS =	1.5
Top of Pile Elevation =	34.5	ft		
Top of Critical Surface Elevation =	34.5	ft		
Bottom of Critical Failure Elevation =	24.5	ft		
Spacing between piles transverse to load application (S) =	6.0	ft	Based on Slope/W analysis	
Number of rows along the direction of the load =	1	row(s)	Center-to-center	

Output Values:

Shear Force per unit of Length =	2,200	lb/ft		
Shear Force per Pile =	13,200	lb	Based on spacing and number of rows	
Depth to Top of Shear Application =	0	ft		
Depth to Bottom of Shear Application =	10	ft		
Length of Shear Application =	10	ft		
Shear Force, P_h =	220	lb/in	per pile	Service Limit State





Lateral Load Distribution from Shear Force

Project Number:	JD205150	Project Engineer:	DK
Project Name:	Arkendale to Powells Creek, 3rd Track	Principal Engineer:	SU
Project Location:	Prince William County, Virginia	Date:	6/9/2020
Structure:	Retaining Wall No. 13 - Station 8263+00		

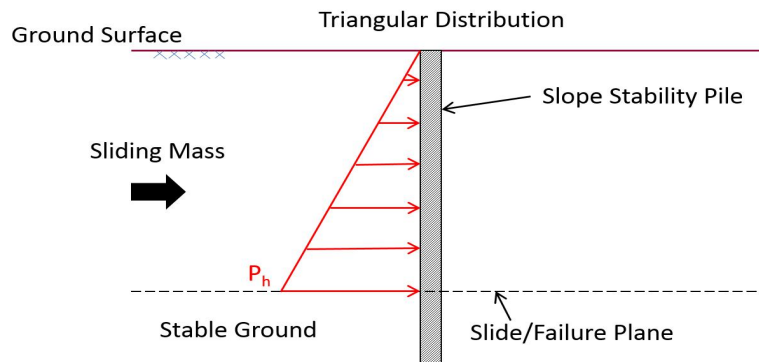
The Slope/W program calculated the *horizontal earth pressure* resultant load for the given pile spacing as shown in slope stability section of the report; however, for proper structural analysis of pile reaction, we converted this to a more realistic distributed load. For this purpose, we used triangular distribution for the approximation of the actual condition to develop a realistic calculation of distributed shear, moment, and displacement in the pile. Utilizing these known factors, we calculated a triangular distribution of loading from zero (0) at the top of the pile to a maximum at the depth of the shear surface from global stability analysis.

Input Values:

Shear Force Required from Piles to achieve the desired FOS =	1,100	lb/ft	for FOS =	1.5
Top of Pile Elevation =	34.5	ft		
Top of Critical Surface Elevation =	34.5	ft		
Bottom of Critical Failure Elevation =	24.5	ft		
Spacing between piles transverse to load application (S) =	6.0	ft	Based on Slope/W analysis	
Number of rows along the direction of the load =	1	row(s)	Center-to-center	

Output Values:

Shear Force per unit of Length =	1,100	lb/ft		
Shear Force per Pile =	6,600	lb	Based on spacing and number of rows	
Depth to Top of Shear Application =	0	ft		
Depth to Bottom of Shear Application =	10	ft		
Length of Shear Application =	10	ft		
Shear Force, P_h =	110	lb/in	per pile	Service Limit State





Lateral Load Distribution from Earth Pressure

Project Number:	JD205150	Project Engineer:	DK
Project Name:	Arkendale to Powells Creek, 3rd Track	Principal Engineer:	SU
Project Location:	Prince William County, Virginia	Date:	6/9/2020
Structure:	Retaining Wall No. 13 - Station 8264+00		

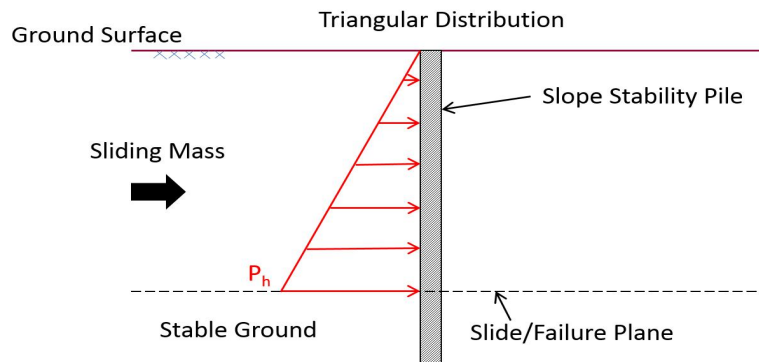
The Slope/W program calculated the *horizontal earth pressure* resultant load for the given pile spacing as shown in slope stability section of the report; however, for proper structural analysis of pile reaction, we converted this to a more realistic distributed load. For this purpose, we used triangular distribution for the approximation of the actual condition to develop a realistic calculation of distributed shear, moment, and displacement in the pile. Utilizing these known factors, we calculated a triangular distribution of loading from zero (0) at the top of the pile to a maximum at the depth of the shear surface from global stability analysis.

Input Values:

Shear Force Required from Piles to achieve the desired FOS =	3,200	lb/ft	for FOS =	1.5
Top of Pile Elevation =	37	ft		
Top of Critical Surface Elevation =	37	ft		
Bottom of Critical Failure Elevation =	25	ft		
Spacing between piles transverse to load application (S) =	6.0	ft	Based on Slope/W analysis	
Number of rows along the direction of the load =	1	row(s)	Center-to-center	

Output Values:

Shear Force per unit of Length =	3,200	lb/ft		
Shear Force per Pile =	19,200	lb	Based on spacing and number of rows	
Depth to Top of Shear Application =	0	ft		
Depth to Bottom of Shear Application =	12	ft		
Length of Shear Application =	12	ft		
Shear Force, P_h =	267	lb/in	per pile	Service Limit State





Lateral Load Distribution from Shear Force

Project Number:	JD205150	Project Engineer:	DK
Project Name:	Arkendale to Powells Creek, 3rd Track	Principal Engineer:	SU
Project Location:	Prince William County, Virginia	Date:	6/9/2020
Structure:	Retaining Wall No. 13 - Station 8264+00		

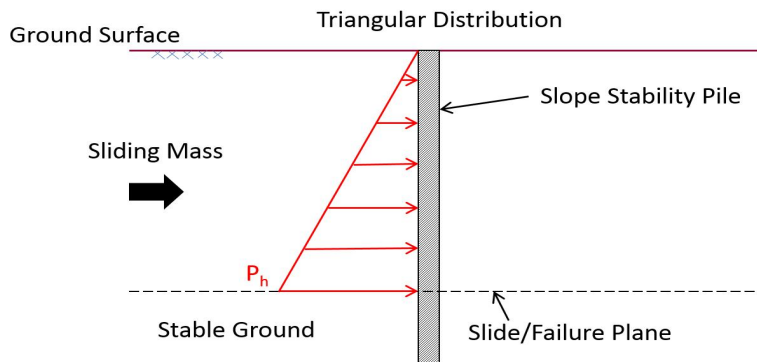
The Slope/W program calculated the *horizontal earth pressure* resultant load for the given pile spacing as shown in slope stability section of the report; however, for proper structural analysis of pile reaction, we converted this to a more realistic distributed load. For this purpose, we used triangular distribution for the approximation of the actual condition to develop a realistic calculation of distributed shear, moment, and displacement in the pile. Utilizing these known factors, we calculated a triangular distribution of loading from zero (0) at the top of the pile to a maximum at the depth of the shear surface from global stability analysis.

Input Values:

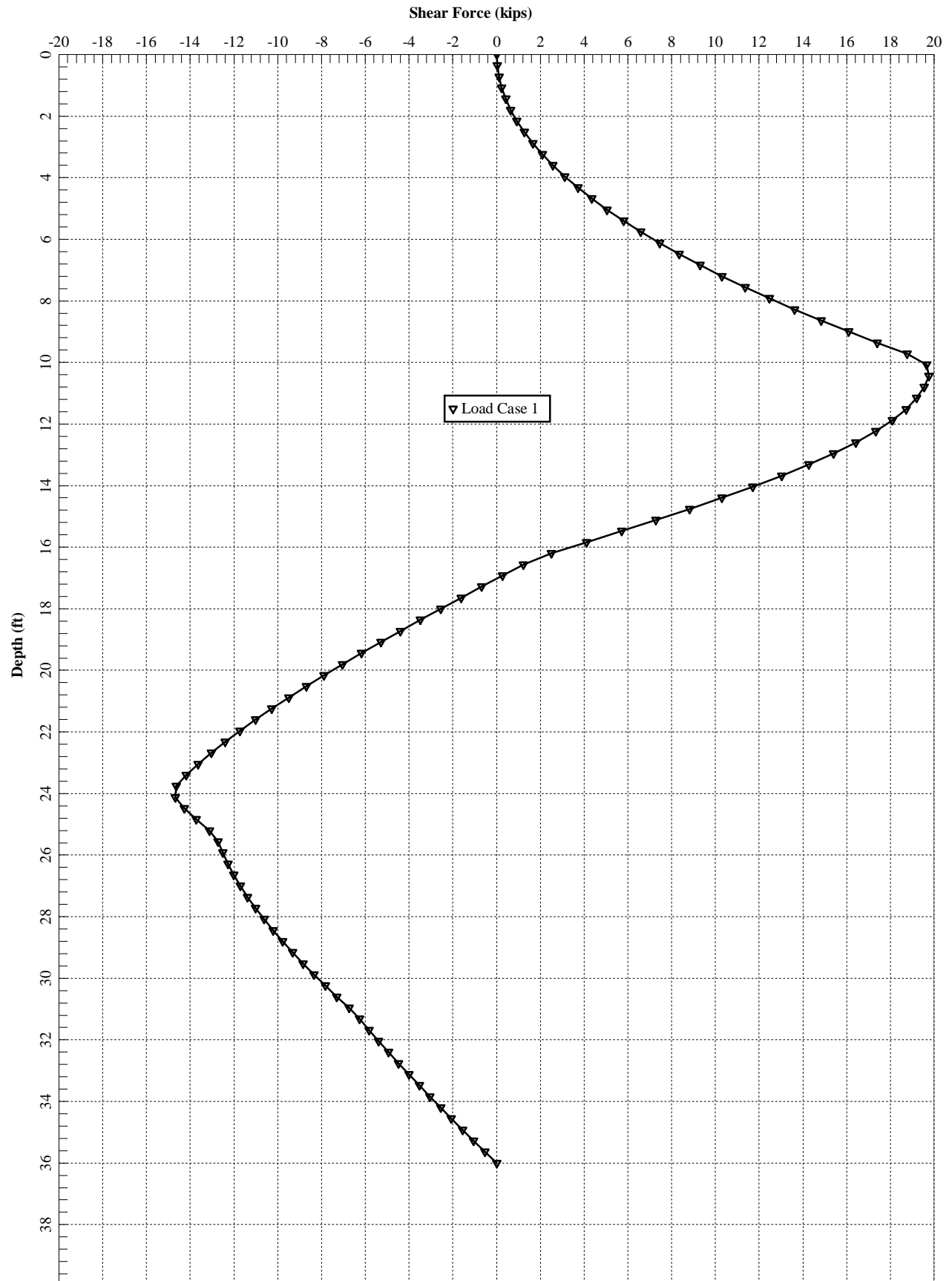
Shear Force Required from Piles to achieve the desired FOS =	1,500	lb/ft	for FOS =	1.5
Top of Pile Elevation =	37	ft		
Top of Critical Surface Elevation =	37	ft		
Bottom of Critical Failure Elevation =	25	ft		
Spacing between piles transverse to load application (S) =	6.0	ft	Based on Slope/W analysis	
Number of rows along the direction of the load =	1	row(s)	Center-to-center	

Output Values:

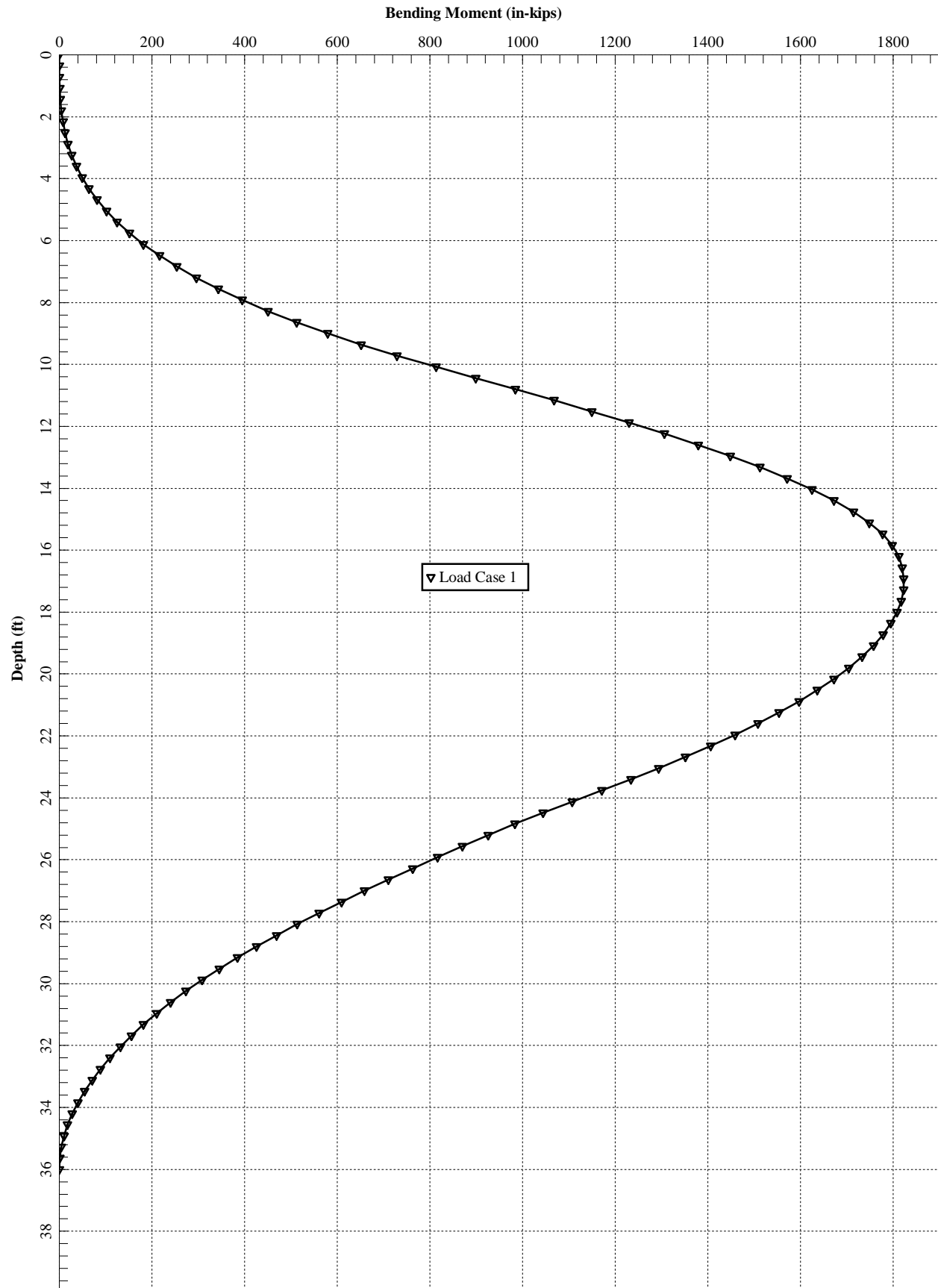
Shear Force per unit of Length =	1,500	lb/ft		
Shear Force per Pile =	9,000	lb	Based on spacing and number of rows	
Depth to Top of Shear Application =	0	ft		
Depth to Bottom of Shear Application =	12	ft		
Length of Shear Application =	12	ft		
Shear Force, P_h =	125	lb/in	per pile	Service Limit State



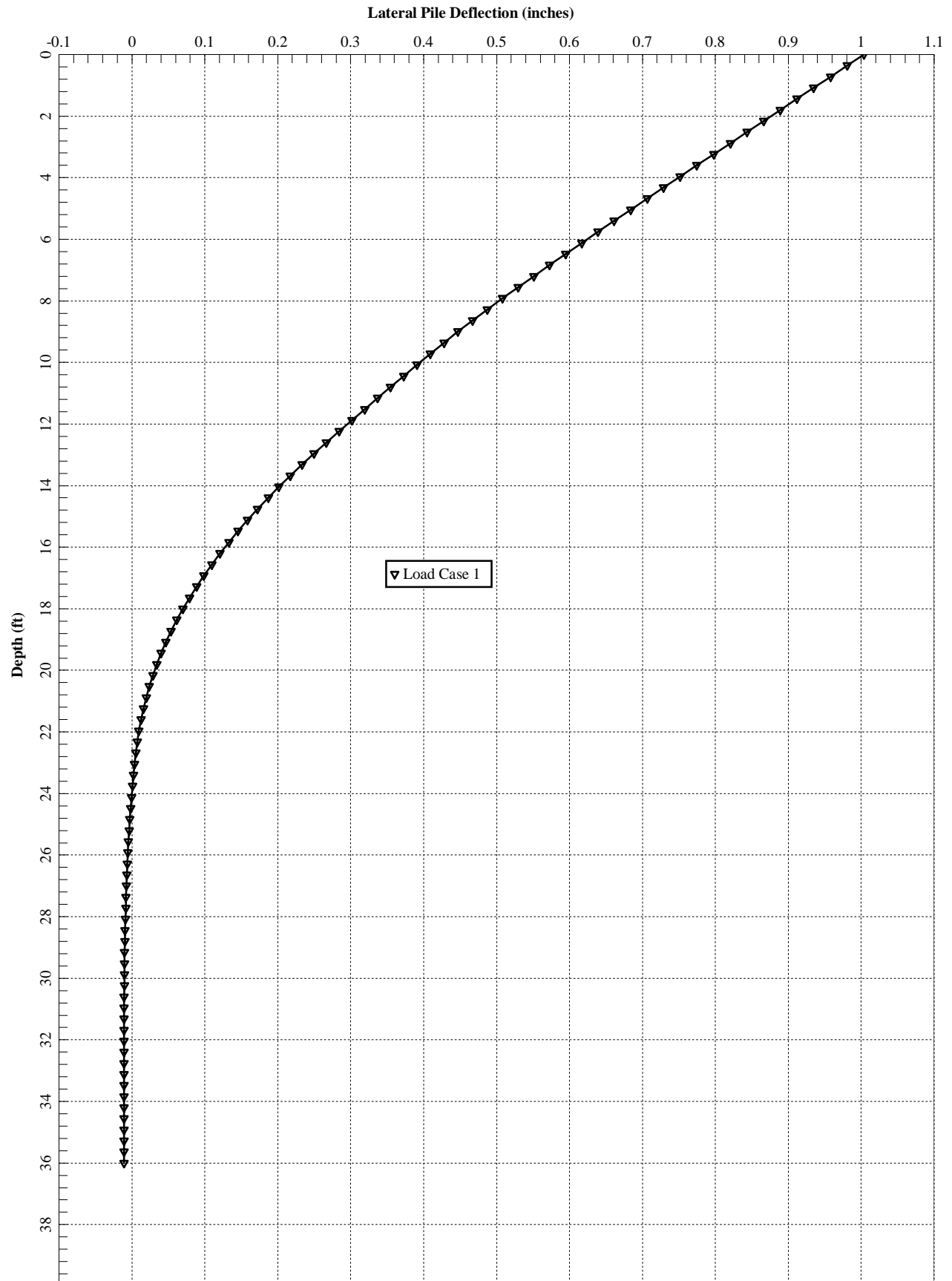
RW-13 Station 8263+00 - Service Load Case



RW-13 Station 8263+00 - Service Load Case



RW-13 Station 8263+00 - Service Load Case



LPile for Windows, Version 2019-11.002

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\\Users\\asgarden\\Desktop\\WFH\\Arkendale\\Stability Pile\\

Name of input data file:
Section A - Slope Stability Pile - Sta 8263+00.lp11

Name of output report file:
Section A - Slope Stability Pile - Sta 8263+00.lp11

Name of plot output file:
Section A - Slope Stability Pile - Sta 8263+00.lp11

Name of runtime message file:
Section A - Slope Stability Pile - Sta 8263+00.lp11

Date and Time of Analysis

Date: June 9, 2020

Time: 10:09:41

Problem Title

Project Name: Arkendale to Powells Creek Third Track Project, RW-13

Job Number: 15184

Client: STV, Inc.

Engineer: FM

Description: Retaining Wall 13 Soldier Pile Wall Sta. 8263+00

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 100 |

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- Analysis includes loading by one distributed lateral load acting on pile
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 36.000 ft
Depth of ground surface below top of pile = 10.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.5800
2	10.000	14.5800
3	10.000	30.0000
4	36.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong H-Pile
Length of section = 10.000000 ft
Flange Width = 14.580000 in
Section Depth = 13.610000 in
Flange Thickness = 0.505000 in
Web Thickness = 0.505000 in
Section Area = 21.088800 sq. in
Moment of Inertia = 716.751440 in^4

Elastic Modulus

=

Section A - Slope Stability Pile - Sta 8263+00.1p11o
29000000. psi

Pile Section No. 2:

Section 2 is a drilled shaft with casing and H section core/insert

Length of section

=

26.000000 ft

Section Diameter

=

30.000000 in

Shear capacity of section

=

0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle

=

0.000 degrees

=

0.000 radians

Pile Batter Angle

=

0.000 degrees

=

0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer

=

10.000000 ft

Distance from top of pile to bottom of layer

=

16.500000 ft

Effective unit weight at top of layer

=

62.600000 pcf

Effective unit weight at bottom of layer

=

62.600000 pcf

Friction angle at top of layer

=

35.000000 deg.

Friction angle at bottom of layer

=

35.000000 deg.

Subgrade k at top of layer

=

60.000000 pci

Subgrade k at bottom of layer

=

60.000000 pci

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer

=

16.500000 ft

Distance from top of pile to bottom of layer

=

25.500000 ft

Effective unit weight at top of layer

=

62.600000 pcf

Effective unit weight at bottom of layer

=

62.600000 pcf

Undrained cohesion at top of layer

=

1000.000000 psf

Undrained cohesion at bottom of layer

=

1000.000000 psf

Epsilon-50 at top of layer
Epsilon-50 at bottom of layer

=
=

0.010000
0.010000

Section A - Slope Stability Pile - Sta 8263+00.l p11o

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer
Distance from top of pile to bottom of layer
Effective unit weight at top of layer
Effective unit weight at bottom of layer
Friction angle at top of layer
Friction angle at bottom of layer
Subgrade k at top of layer
Subgrade k at bottom of layer

=
=
=
=
=
=
=
=

25.500000 ft
31.000000 ft
62.600000 pcf
62.600000 pcf
35.000000 deg.
35.000000 deg.
60.000000 pci
60.000000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer
Distance from top of pile to bottom of layer
Effective unit weight at top of layer
Effective unit weight at bottom of layer
Friction angle at top of layer
Friction angle at bottom of layer
Subgrade k at top of layer
Subgrade k at bottom of layer

=
=
=
=
=
=
=
=

31.000000 ft
50.000000 ft
57.600000 pcf
57.600000 pcf
23.000000 deg.
23.000000 deg.
45.000000 pci
45.000000 pci

(Depth of the lowest soil layer extends 14.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	E50 or krm	kpy pci
1	Sand	10.0000	62.6000	--	35.0000	--	60.0000
	(Reese, et al.)	16.5000	62.6000	--	35.0000	--	60.0000
2	Stiff Clay	16.5000	62.6000	1000.0000	--	0.01000	--
	w/o Free Water	25.5000	62.6000	1000.0000	--	0.01000	--
3	Sand	25.5000	62.6000	--	35.0000	--	60.0000
	(Reese, et al.)	31.0000	62.6000	--	35.0000	--	60.0000
4	Sand	31.0000	57.6000	--	23.0000	--	45.0000
	(Reese, et al.)	50.0000	57.6000	--	23.0000	--	45.0000

Section A - Slope Stability Pile - Sta 8263+00.l p11o

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.8000	1.0000
2	50.000	0.8000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	0.000
2	120.000	331.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	No	Yes

Section A - Slope Stability Pile - Sta 8263+00.lp11o

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and H Strong Axis Core/Insert:

Length of Section	=	26.000000 ft
Outside Diameter of Casing	=	30.000000 in
Concrete Cover Thickness Inside Casing	=	3.000000 in
Casing Wall Thickness	=	0.0000 in
Moment of Inertia of Steel Casing	=	0.0000 in^4
Width Flange of Core/Insert	=	14.580000 in
Depth of Core/Insert	=	13.610000 in
Flange Thickness of Core/Insert	=	0.505000 in
Web Thickness of Core/Insert	=	0.505000 in
Moment of Inertia of Steel Core/Insert	=	716.751440 in^4
Yield Stress of Casing	=	36000. psi
Elastic Modulus of Casing	=	29000000. psi
Yield Stress of Core/Insert	=	50000. psi
Elastic Modulus of Core/Insert	=	29000000. psi
Number of Reinforcing Bars	=	12 bars
Area of Single Reinforcing Bar	=	0.0000 sq. in.
Area of All Reinforcing Bars	=	0.0000 sq. in.
Edge-to-Edge Bar Spacing	=	6.211657 in

		Section A - Slope Stability Pile - Sta 8263+00.Lp11o
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	8.28
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	706.858347 sq. in.
Area of Concrete	=	685.769547 sq. in.
Cross-sectional Area of Steel Casing	=	0.0000 sq. in.
Cross-sectional Area of Steel Core/Insert	=	21.088800 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	21.088800 sq. in.
Area Ratio of All Steel to Gross Area	=	2.98 percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	3386.056 kips
Tensile Load for Cracking of Concrete	=	-355.776 kips
Nominal Axial Tensile Capacity	=	-1054.440 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----
1	0.0000	0.0000	12.000000	0.000000
2	0.0000	0.0000	10.392305	6.000000
3	0.0000	0.0000	6.000000	10.392305
4	0.0000	0.0000	0.000000	12.000000
5	0.0000	0.0000	-6.000000	10.392305
6	0.0000	0.0000	-10.392305	6.000000
7	0.0000	0.0000	-12.000000	0.000000
8	0.0000	0.0000	-10.392305	-6.000000
9	0.0000	0.0000	-6.000000	-10.392305
10	0.0000	0.0000	0.000000	-12.000000
11	0.0000	0.0000	6.000000	-10.392305
12	0.0000	0.0000	10.392305	-6.000000

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 6.212 inches
between bars 9 and 10.

Ratio of bar spacing to maximum aggregate size = 8.28

Section A - Slope Stability Pile - Sta 8263+00.1p11o

Concrete Properties:

Compressive Strength of Concrete = 4000. psi
Modulus of Elasticity of Concrete = 3604997. psi
Modulus of Rupture of Concrete = -474.341649 psi
Compression Strain at Peak Stress = 0.001886
Tensile Strain at Fracture of Concrete = -0.0001154
Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
0.00000125	232.4085198	185926816.	15.0000000	0.00001875	-0.00001875	0.0783394	0.00000	0.00000	0.2446875	
0.00000250	463.4099867	185363995.	15.0000000	0.00003750	-0.00003750	0.1559041	0.00000	0.00000	0.4893750	
0.00000375	693.0044009	184801174.	15.0000000	0.00005625	-0.00005625	0.2326940	0.00000	0.00000	0.7340625	
0.00000500	921.1917623	184238352.	15.0000000	0.00007500	-0.00007500	0.3087091	0.00000	0.00000	0.9787500	
0.00000625	1148.	183675531.	15.0000000	0.00009375	-0.00009375	0.3839496	0.00000	0.00000	1.2234375	
0.00000750	1373.	183112710.	15.0000000	0.0001125	-0.0001125	0.4584153	0.00000	0.00000	1.4681250	
0.00000875	1373.	156953752.	9.6708280	0.00008462	-0.0001779	0.3455182	0.00000	0.00000	-3.0650901	C

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0.00001000	1373.	137334533.	9.6753056	0.00009675	-0.0002032	0.3937844	0.00000	0.00000	-3.5016613 C
0.00001125	1373.	122075140.	9.6797974	0.0001089	-0.0002286	0.4417752	0.00000	0.00000	-3.9379036 C
0.00001250	1373.	109867626.	9.6843036	0.0001211	-0.0002539	0.4894898	0.00000	0.00000	-4.3738149 C
0.00001375	1373.	99879660.	9.6888241	0.0001332	-0.0002793	0.5369276	0.00000	0.00000	-4.8093939 C
0.00001500	1373.	91556355.	9.6933591	0.0001454	-0.0003046	0.5840879	0.00000	0.00000	-5.2446387 C
0.00001625	1373.	84513559.	9.6979087	0.0001576	-0.0003299	0.6309699	0.00000	0.00000	-5.6795480 C
0.00001750	1373.	78476876.	9.7024730	0.0001698	-0.0003552	0.6775729	0.00000	0.00000	-6.1141199 C
0.00001875	1373.	73245084.	9.7070521	0.0001820	-0.0003805	0.7238961	0.00000	0.00000	-6.5483529 C
0.00002000	1373.	68667266.	9.7116460	0.0001942	-0.0004058	0.7699390	0.00000	0.00000	-6.9822452 C
0.00002125	1373.	64628015.	9.7162550	0.0002065	-0.0004310	0.8157006	0.00000	0.00000	-7.4157953 C
0.00002250	1373.	61037570.	9.7208790	0.0002187	-0.0004563	0.8611804	0.00000	0.00000	-7.8490014 C
0.00002375	1373.	57825066.	9.7255181	0.0002310	-0.0004815	0.9063775	0.00000	0.00000	-8.2818618 C
0.00002500	1405.	56192885.	9.7301726	0.0002433	-0.0005067	0.9512912	0.00000	0.00000	-8.7143748 C
0.00002625	1474.	56150509.	9.7348424	0.0002555	-0.0005320	0.9959207	0.00000	0.00000	-9.1465386 C
0.00002750	1543.	56108011.	9.7395277	0.0002678	-0.0005572	1.0402652	0.00000	0.00000	-9.5783516 C
0.00002875	1612.	56065390.	9.7442286	0.0002801	-0.0005824	1.0843241	0.00000	0.00000	-10.0098118 C
0.00003000	1681.	56022645.	9.7489452	0.0002925	-0.0006075	1.1280965	0.00000	0.00000	-10.4409176 C
0.00003125	1749.	55979792.	9.7535843	0.0003048	-0.0006327	1.1715713	0.00000	0.00000	-10.8717516 C
0.00003250	1818.	55936821.	9.7582118	0.0003171	-0.0006579	1.2147542	0.00000	0.00000	-11.3022602 C
0.00003375	1886.	55893727.	9.7628546	0.0003295	-0.0006830	1.2576473	0.00000	0.00000	-11.7324185 C
0.00003500	1955.	55850510.	9.7675126	0.0003419	-0.0007081	1.3002499	0.00000	0.00000	-12.1622246 C
0.00003625	2023.	55807168.	9.7721861	0.0003542	-0.0007333	1.3425612	0.00000	0.00000	-12.5916768 C
0.00003750	2091.	55763702.	9.7768750	0.0003666	-0.0007584	1.3845804	0.00000	0.00000	-13.0207733 C
0.00003875	2159.	55720110.	9.7815796	0.0003790	-0.0007835	1.4263066	0.00000	0.00000	-13.4495123 C
0.00004000	2227.	55676392.	9.7862999	0.0003915	-0.0008085	1.4677392	0.00000	0.00000	-13.8778919 C
0.00004125	2295.	55632547.	9.7910361	0.0004039	-0.0008336	1.5088772	0.00000	0.00000	-14.3059104 C
0.00004250	2363.	55588573.	9.7957882	0.0004163	-0.0008587	1.5497198	0.00000	0.00000	-14.7335659 C
0.00004375	2430.	55544470.	9.8005564	0.0004288	-0.0008837	1.5902663	0.00000	0.00000	-15.1608565 C
0.00004500	2498.	55500238.	9.8053407	0.0004412	-0.0009088	1.6305158	0.00000	0.00000	-15.5877803 C
0.00004625	2565.	55455875.	9.8101413	0.0004537	-0.0009338	1.6704675	0.00000	0.00000	-16.0143354 C
0.00004750	2632.	55411381.	9.8149583	0.0004662	-0.0009588	1.7101205	0.00000	0.00000	-16.4405198 C
0.00004875	2699.	55366755.	9.8197918	0.0004787	-0.0009838	1.7494740	0.00000	0.00000	-16.8663318 C
0.00005125	2833.	55277101.	9.8295087	0.0005038	-0.0010337	1.8272789	0.00000	0.00000	-17.7168300 C
0.00005375	2966.	55186909.	9.8392931	0.0005289	-0.0010836	1.9038755	0.00000	0.00000	-18.5658142 C
0.00005625	3099.	55096170.	9.8491458	0.0005540	-0.0011335	1.9792567	0.00000	0.00000	-19.4132682 C
0.00005875	3232.	55004877.	9.8590679	0.0005792	-0.0011833	2.0534153	0.00000	0.00000	-20.2591753 C
0.00006125	3363.	54913023.	9.8690604	0.0006045	-0.0012330	2.1263441	0.00000	0.00000	-21.1035188 C
0.00006375	3495.	54820600.	9.8791242	0.0006298	-0.0012827	2.1980357	0.00000	0.00000	-21.9462814 C
0.00006625	3626.	54727601.	9.8892605	0.0006552	-0.0013323	2.2684827	0.00000	0.00000	-22.7874456 C
0.00006875	3756.	54634017.	9.8994702	0.0006806	-0.0013819	2.3376774	0.00000	0.00000	-23.6269935 C
0.00007125	3886.	54539840.	9.9097546	0.0007061	-0.0014314	2.4056122	0.00000	0.00000	-24.4649069 C
0.00007375	4015.	54445063.	9.9201146	0.0007316	-0.0014809	2.4722791	0.00000	0.00000	-25.3011672 C
0.00007625	4144.	54349676.	9.9305515	0.0007572	-0.0015303	2.5376701	0.00000	0.00000	-26.1357553 C
0.00007875	4272.	54253671.	9.9410664	0.0007829	-0.0015796	2.6017771	0.00000	0.00000	-26.9686520 C
0.00008125	4400.	54157040.	9.9516604	0.0008086	-0.0016289	2.6645919	0.00000	0.00000	-27.7998374 C
0.00008375	4528.	54059773.	9.9623349	0.0008343	-0.0016782	2.7261061	0.00000	0.00000	-28.6292913 C
0.00008625	4654.	53961855.	9.9730911	0.0008602	-0.0017273	2.7863108	0.00000	0.00000	-29.4569955 C
0.00008875	4780.	53863288.	9.9839303	0.0008861	-0.0017764	2.8451977	0.00000	0.00000	-30.2829240 C
0.00009125	4906.	53764058.	9.9948537	0.0009120	-0.0018255	2.9027578	0.00000	0.00000	-31.1070578 C

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0.00009375	5031.	53664153.	10.0058627	0.0009380	-0.0018745	2.9589820	0.00000	0.00000	-31.9293749 C
0.00009625	5155.	53563564.	10.0169588	0.0009641	-0.0019234	3.0138612	0.00000	0.00000	-32.7498528 C
0.00009875	5279.	53462281.	10.0281432	0.0009903	-0.0019722	3.0673858	0.00000	0.00000	-33.5684687 C
0.0001013	5403.	53360292.	10.0394175	0.0010165	-0.0020210	3.1195465	0.00000	0.00000	-34.3851990 C
0.0001038	5525.	53257599.	10.0507614	0.0010428	-0.0020697	3.1703291	0.00000	0.00000	-35.2000851 C
0.0001063	5648.	53154365.	10.0619010	0.0010691	-0.0021184	3.2196689	0.00000	0.00000	-36.0139558 C
0.0001088	5769.	53050414.	10.0731300	0.0010955	-0.0021670	3.2676150	0.00000	0.00000	-36.8259298 C
0.0001113	5890.	52945737.	10.0844496	0.0011219	-0.0022156	3.3141574	0.00000	0.00000	-37.6359827 C
0.0001138	6011.	52840322.	10.0958616	0.0011484	-0.0022641	3.3592859	0.00000	0.00000	-38.4440898 C
0.0001163	6130.	52734156.	10.1073674	0.0011750	-0.0023125	3.4029901	0.00000	0.00000	-39.2502258 C
0.0001188	6249.	52627229.	10.1189687	0.0012016	-0.0023609	3.4452594	0.00000	0.00000	-40.0543648 C
0.0001213	6368.	52519528.	10.1306670	0.0012283	-0.0024092	3.4860829	0.00000	0.00000	-40.8564802 C
0.0001238	6486.	52411041.	10.1424641	0.0012551	-0.0024574	3.5254497	0.00000	0.00000	-41.6565450 C
0.0001263	6603.	52301754.	10.1543617	0.0012820	-0.0025055	3.5633485	0.00000	0.00000	-42.4545312 C
0.0001288	6720.	52191655.	10.1663616	0.0013089	-0.0025536	3.5997678	0.00000	0.00000	-43.2504103 C
0.0001313	6836.	52080729.	10.1784656	0.0013359	-0.0026016	3.6346959	0.00000	0.00000	-44.0441533 C
0.0001338	6951.	51968964.	10.1906755	0.0013630	-0.0026495	3.6681207	0.00000	0.00000	-44.8357302 C
0.0001363	7065.	51856345.	10.2029933	0.0013902	-0.0026973	3.7000302	0.00000	0.00000	-45.6251103 C
0.0001388	7179.	51742857.	10.2154210	0.0014174	-0.0027451	3.7304118	0.00000	0.00000	-46.4122622 C
0.0001413	7293.	51628485.	10.2279606	0.0014447	-0.0027928	3.7592527	0.00000	0.00000	-47.1971537 C
0.0001438	7405.	51513214.	10.2406143	0.0014721	-0.0028404	3.7865398	0.00000	0.00000	-47.9797517 C
0.0001463	7517.	51397028.	10.2533840	0.0014996	-0.0028879	3.8122600	0.00000	0.00000	-48.7600223 C
0.0001488	7628.	51279910.	10.2662721	0.0015271	-0.0029354	3.8363994	0.00000	0.00000	-49.5379308 C
0.0001588	7894.	49724658.	10.2299115	0.0016240	-0.0031385	3.9079886	0.00000	0.00000	-50.0000000 CY
0.0001688	8027.	47569183.	10.1400274	0.0017111	-0.0033514	3.9548268	0.00000	0.00000	-50.0000000 CY
0.0001788	8143.	45555913.	10.0573242	0.0017977	-0.0035648	3.9850450	0.00000	0.00000	-50.0000000 CY
0.0001888	8243.	43671738.	9.9785181	0.0018834	-0.0037791	3.9989100	0.00000	0.00000	-50.0000000 CY
0.0001988	8330.	41910675.	9.9061627	0.0019688	-0.0039937	3.9999471	0.00000	0.00000	-50.0000000 CY
0.0002088	8405.	40264199.	9.8405939	0.0020542	-0.0042083	3.9970490	0.00000	0.00000	-50.0000000 CY
0.0002188	8470.	38721586.	9.7809842	0.0021396	-0.0044229	3.9980175	0.00000	0.00000	-50.0000000 CY
0.0002288	8527.	37277344.	9.7260586	0.0022248	-0.0046377	3.9983012	0.00000	0.00000	-50.0000000 CY
0.0002388	8576.	35920642.	9.6745177	0.0023098	-0.0048527	3.9980129	0.00000	0.00000	-50.0000000 CY
0.0002488	8619.	34648028.	9.6276066	0.0023949	-0.0050676	3.9970654	0.00000	0.00000	-50.0000000 CY
0.0002588	8656.	33453186.	9.5848574	0.0024801	-0.0052824	3.9963558	0.00000	0.00000	-50.0000000 CY
0.0002688	8689.	32329895.	9.5458574	0.0025654	-0.0054971	3.9999577	0.00000	0.00000	-50.0000000 CY
0.0002788	8717.	31272392.	9.5103356	0.0026510	-0.0057115	3.9990082	0.00000	0.00000	-50.0000000 CY
0.0002888	8742.	30276308.	9.4778694	0.0027367	-0.0059258	3.9960735	0.00000	0.00000	-50.0000000 CY
0.0002988	8764.	29335160.	9.4475925	0.0028225	-0.0061400	3.9999734	0.00000	0.00000	-50.0000000 CY
0.0003088	8782.	28445118.	9.4185276	0.0029080	-0.0063545	3.9978739	0.00000	0.00000	-50.0000000 CY
0.0003188	8799.	27604509.	9.3918112	0.0029936	-0.0065689	3.9975917	0.00000	0.00000	-50.0000000 CY
0.0003288	8813.	26807430.	9.3671794	0.0030795	-0.0067830	3.9982350	0.00000	0.00000	-50.0000000 CY
0.0003388	8825.	26051940.	9.3442502	0.0031654	-0.0069971	3.9972468	0.00000	0.00000	-50.0000000 CY
0.0003488	8836.	25335347.	9.3235219	0.0032516	-0.0072109	3.9975028	0.00000	0.00000	-50.0000000 CY
0.0003588	8844.	24653533.	9.3037208	0.0033377	-0.0074248	3.9999975	0.00000	0.00000	-50.0000000 CY
0.0003688	8852.	24005723.	9.2861265	0.0034243	-0.0076382	3.9950919	0.00000	0.00000	-50.0000000 CY
0.0003788	8858.	23387790.	9.2691598	0.0035107	-0.0078518	3.9993981	0.00000	0.00000	-50.0000000 CY
0.0003888	8863.	22799698.	9.2539068	0.0035975	-0.0080650	3.9936911	0.00000	0.00000	-50.0000000 CY
0.0003988	8867.	22237692.	9.2395415	0.0036843	-0.0082782	3.9964503	0.00000	0.00000	-50.0000000 CY
0.0004088	8870.	21701411.	9.2261763	0.0037712	-0.0084913	3.9997208	0.00000	0.00000	-50.0000000 CY

0.00041888870.21183169.9.2340098Section A - Slope Stability Pile - Sta 8263+00.1p11o0.0038667-0.00869583.99041380.000000.000000-50.0000000 CY

Summary of Results for Nominal Moment Capacity for Section 2

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	0.000	8799.975	0.00300000

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	8800.	0.0000	5720.	53092521.
1	0.75	8800.	0.0000	6600.	52304658.
1	0.90	8800.	0.0000	7920.	49301858.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head	Equivalent Top Depth Below Grnd Surf	Same Layer Type As Layer	Layer is Rock or is Below	F0 Integral for Layer	F1 Integral for Layer
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	ft	ft	Above	Rock Layer	lbs	lbs
1	10.0000	0.00	N. A.	No	0.00	44281.
2	16.5000	4.8672	No	No	44281.	122846.
3	25.5000	12.4675	No	No	167127.	249656.
4	31.0000	25.8682	Yes	No	416783.	N. A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi *	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	1.0036	2.47E-07	0.00	-0.00530	2.52E-09	2.08E+10	0.00	0.00	2.9790
0.3600	0.9807	27.7976	32.1732	-0.00530	0.2827	2.08E+10	0.00	0.00	11.9160
0.7200	0.9578	277.9764	109.3889	-0.00530	2.8273	2.08E+10	0.00	0.00	23.8320
1.0800	0.9349	972.9176	238.0817	-0.00530	9.8954	2.08E+10	0.00	0.00	35.7480
1.4400	0.9120	2335.	418.2516	-0.00530	23.7490	2.08E+10	0.00	0.00	47.6640
1.8000	0.8891	4587.	649.8986	-0.00530	46.6499	2.08E+10	0.00	0.00	59.5800
2.1600	0.8662	7950.	933.0228	-0.00530	80.8599	2.08E+10	0.00	0.00	71.4960
2.5200	0.8433	12648.	1268.	-0.00530	128.6407	2.08E+10	0.00	0.00	83.4120
2.8800	0.8204	18902.	1654.	-0.00529	192.2542	2.08E+10	0.00	0.00	95.3280
3.2400	0.7976	26936.	2091.	-0.00529	273.9623	2.08E+10	0.00	0.00	107.2440
3.6000	0.7747	36971.	2580.	-0.00528	376.0266	2.08E+10	0.00	0.00	119.1600
3.9600	0.7519	49230.	3121.	-0.00527	500.7091	2.08E+10	0.00	0.00	131.0760
4.3200	0.7292	63935.	3713.	-0.00526	650.2716	2.08E+10	0.00	0.00	142.9920
4.6800	0.7065	81308.	4356.	-0.00525	826.9758	2.08E+10	0.00	0.00	154.9080
5.0400	0.6838	101573.	5051.	-0.00523	1033.	2.08E+10	0.00	0.00	166.8240
5.4000	0.6613	124950.	5798.	-0.00520	1271.	2.08E+10	0.00	0.00	178.7400
5.7600	0.6389	151664.	6596.	-0.00518	1543.	2.08E+10	0.00	0.00	190.6560
6.1200	0.6166	181936.	7445.	-0.00514	1850.	2.08E+10	0.00	0.00	202.5720

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6. 4800	0. 5944	215988.	8346.	-0. 00510	2197.	2. 08E+10	0. 00	0. 00	214. 4880
6. 8400	0. 5725	254043.	9298.	-0. 00505	2584.	2. 08E+10	0. 00	0. 00	226. 4040
7. 2000	0. 5508	296323.	10302.	-0. 00499	3014.	2. 08E+10	0. 00	0. 00	238. 3200
7. 5600	0. 5294	343051.	11357.	-0. 00493	3489.	2. 08E+10	0. 00	0. 00	250. 2360
7. 9200	0. 5082	394449.	12464.	-0. 00485	4012.	2. 08E+10	0. 00	0. 00	262. 1520
8. 2800	0. 4875	450739.	13622.	-0. 00476	4584.	2. 08E+10	0. 00	0. 00	274. 0680
8. 6400	0. 4671	512144.	14832.	-0. 00466	5209.	2. 08E+10	0. 00	0. 00	285. 9840
9. 0000	0. 4472	578886.	16093.	-0. 00455	5888.	2. 08E+10	0. 00	0. 00	297. 9000
9. 3600	0. 4278	651188.	17406.	-0. 00442	6623.	2. 08E+10	0. 00	0. 00	309. 8160
9. 7200	0. 4090	729271.	18770.	-0. 00428	7417.	2. 08E+10	0. 00	0. 00	321. 7320
10. 0800	0. 3908	813359.	19650.	-0. 00419	0. 00	1. 84E+11	-5. 8340	64. 4851	91. 4847
10. 4400	0. 3728	899045.	19761.	-0. 00417	0. 00	1. 84E+11	-33. 9874	393. 8868	0. 00
10. 8000	0. 3548	984097.	19549.	-0. 00415	0. 00	1. 84E+11	-64. 4668	784. 9816	0. 00
11. 1600	0. 3369	1067946.	19202.	-0. 00413	0. 00	1. 84E+11	-96. 2191	1234.	0. 00
11. 5200	0. 3191	1150000.	18716.	-0. 00410	0. 00	1. 84E+11	-128. 7798	1743.	0. 00
11. 8800	0. 3015	1229650.	18089.	-0. 00407	0. 00	1. 83E+11	-161. 2556	2311.	0. 00
12. 2400	0. 2839	1306290.	17325.	-0. 00404	0. 00	1. 83E+11	-192. 6497	2931.	0. 00
12. 6000	0. 2666	1379335.	16428.	-0. 00398	0. 00	5. 75E+10	-222. 4018	3604.	0. 00
12. 9600	0. 2496	1448230.	15407.	-0. 00387	0. 00	5. 62E+10	-250. 5081	4336.	0. 00
13. 3200	0. 2331	1512449.	14270.	-0. 00375	0. 00	5. 61E+10	-275. 7197	5109.	0. 00
13. 6800	0. 2172	1571523.	13032.	-0. 00363	0. 00	5. 61E+10	-297. 4156	5916.	0. 00
14. 0400	0. 2017	1625047.	11703.	-0. 00351	0. 00	5. 61E+10	-318. 0295	6811.	0. 00
14. 4000	0. 1868	1672635.	10291.	-0. 00338	0. 00	5. 60E+10	-335. 5576	7759.	0. 00
14. 7600	0. 1725	1713961.	8813.	-0. 00325	0. 00	5. 60E+10	-348. 9117	8739.	0. 00
15. 1200	0. 1587	1748776.	7283.	-0. 00312	0. 00	5. 60E+10	-359. 0748	9774.	0. 00
15. 4800	0. 1455	1776889.	5714.	-0. 00298	0. 00	5. 60E+10	-367. 6763	10915.	0. 00
15. 8400	0. 1329	1798140.	4116.	-0. 00285	0. 00	5. 59E+10	-371. 9882	12089.	0. 00
16. 2000	0. 1209	1812450.	2509.	-0. 00271	0. 00	5. 59E+10	-371. 8058	13282.	0. 00
16. 5600	0. 1095	1819820.	1228.	-0. 00257	0. 00	5. 59E+10	-221. 2055	8724.	0. 00
16. 9200	0. 09875	1823063.	274. 7036	-0. 00243	0. 00	5. 59E+10	-220. 2926	9637.	0. 00
17. 2800	0. 08858	1822194.	-674. 1725	-0. 00229	0. 00	5. 59E+10	-219. 0019	10681.	0. 00
17. 6400	0. 07901	1817238.	-1617.	-0. 00214	0. 00	5. 59E+10	-217. 3194	11883.	0. 00
18. 0000	0. 07004	1808226.	-2551.	-0. 00200	0. 00	5. 59E+10	-215. 2302	13274.	0. 00
18. 3600	0. 06168	1795198.	-3475.	-0. 00187	0. 00	5. 60E+10	-212. 7182	14897.	0. 00
18. 7200	0. 05392	1778199.	-4388.	-0. 00173	0. 00	5. 60E+10	-209. 7661	16805.	0. 00
19. 0800	0. 04676	1757286.	-5287.	-0. 00159	0. 00	5. 60E+10	-206. 3550	19066.	0. 00
19. 4400	0. 04018	1732522.	-6170.	-0. 00146	0. 00	5. 60E+10	-202. 4649	21771.	0. 00
19. 8000	0. 03417	1703980.	-7035.	-0. 00132	0. 00	5. 60E+10	-198. 0747	25041.	0. 00
20. 1600	0. 02873	1671741.	-7880.	-0. 00119	0. 00	5. 60E+10	-193. 1628	29041.	0. 00
20. 5200	0. 02385	1635897.	-8703.	-0. 00107	0. 00	5. 61E+10	-187. 7083	33993.	0. 00
20. 8800	0. 01952	1596550.	-9501.	-9. 42E-04	0. 00	5. 61E+10	-181. 6933	40211.	0. 00
21. 2400	0. 01572	1553812.	-10271.	-8. 21E-04	0. 00	5. 61E+10	-175. 1079	48132.	0. 00
21. 6000	0. 01243	1507806.	-11012.	-7. 03E-04	0. 00	5. 61E+10	-167. 9593	58375.	0. 00
21. 9600	0. 00964	1458666.	-11721.	-5. 89E-04	0. 00	5. 62E+10	-160. 2896	71798.	0. 00
22. 3200	0. 00734	1406534.	-12396.	-4. 78E-04	0. 00	5. 62E+10	-152. 2109	89538.	0. 00
22. 6800	0. 00551	1351562.	-13036.	-4. 08E-04	0. 00	1. 83E+11	-143. 9707	112870.	0. 00
23. 0400	0. 00381	1293903.	-13635.	-3. 77E-04	0. 00	1. 83E+11	-133. 4270	151105.	0. 00
23. 4000	0. 00225	1233753.	-14180.	-3. 48E-04	0. 00	1. 83E+11	-118. 7819	228002.	0. 00
23. 7600	8. 12E-04	1171387.	-14639.	-3. 19E-04	0. 00	1. 84E+11	-93. 4908	497323.	0. 00

Section A - Slope Stability Pile - Sta 8263+00.1p11o									
24.1200	-5.07E-04	1107277.	-14680.	-2.92E-04	0.00	1.84E+11	74.4070	633614.	0.00
24.4800	-0.00171	1044554.	-14268.	-2.67E-04	0.00	1.84E+11	116.1354	292663.	0.00
24.8400	-0.00282	984000.	-13729.	-2.43E-04	0.00	1.84E+11	133.4189	204732.	0.00
25.2000	-0.00382	925935.	-13125.	-2.21E-04	0.00	1.84E+11	146.0677	165341.	0.00
25.5600	-0.00472	870596.	-12718.	-2.00E-04	0.00	1.84E+11	42.3374	38718.	0.00
25.9200	-0.00554	816047.	-12517.	-1.80E-04	0.00	1.84E+11	50.8294	39614.	0.00
26.2800	-0.00628	762447.	-12280.	-1.62E-04	0.00	1.85E+11	58.8870	40510.	0.00
26.6400	-0.00694	709946.	-12009.	-1.44E-04	0.00	1.85E+11	66.5112	41406.	0.00
27.0000	-0.00753	658686.	-11707.	-1.28E-04	0.00	1.85E+11	73.7067	42301.	0.00
27.3600	-0.00805	608801.	-11373.	-1.14E-04	0.00	1.85E+11	80.4811	43197.	0.00
27.7200	-0.00851	560419.	-11012.	-9.99E-05	0.00	1.85E+11	86.8448	44093.	0.00
28.0800	-0.00891	513657.	-10624.	-8.74E-05	0.00	1.85E+11	92.8107	44989.	0.00
28.4400	-0.00926	468628.	-10211.	-7.59E-05	0.00	1.85E+11	98.3941	45885.	0.00
28.8000	-0.00957	425434.	-9775.	-6.55E-05	0.00	1.85E+11	103.6124	46780.	0.00
29.1600	-0.00983	384175.	-9317.	-5.61E-05	0.00	1.85E+11	108.4845	47676.	0.00
29.5200	-0.01005	344939.	-8838.	-4.76E-05	0.00	1.86E+11	113.0304	48572.	0.00
29.8800	-0.01024	307814.	-8341.	-4.00E-05	0.00	1.86E+11	117.2716	49468.	0.00
30.2400	-0.01040	272877.	-7825.	-3.33E-05	0.00	1.86E+11	121.2301	50364.	0.00
30.6000	-0.01053	240202.	-7294.	-2.73E-05	0.00	1.86E+11	124.9286	51259.	0.00
30.9600	-0.01063	209859.	-6747.	-2.21E-05	0.00	1.86E+11	128.3899	52155.	0.00
31.3200	-0.01072	181911.	-6256.	-1.75E-05	0.00	1.86E+11	98.7273	39788.	0.00
31.6800	-0.01079	155807.	-5825.	-1.36E-05	0.00	1.86E+11	101.0175	40460.	0.00
32.0400	-0.01084	131587.	-5383.	-1.03E-05	0.00	1.86E+11	103.1796	41132.	0.00
32.4000	-0.01087	109294.	-4933.	-7.45E-06	0.00	1.86E+11	105.2296	41804.	0.00
32.7600	-0.01090	88963.	-4475.	-5.15E-06	0.00	1.86E+11	107.1835	42476.	0.00
33.1200	-0.01092	70634.	-4007.	-3.30E-06	0.00	1.86E+11	109.0566	43147.	0.00
33.4800	-0.01093	54339.	-3532.	-1.85E-06	0.00	1.86E+11	110.8632	43819.	0.00
33.8400	-0.01093	40114.	-3050.	-7.48E-07	0.00	1.86E+11	112.6170	44491.	0.00
34.2000	-0.01094	27990.	-2559.	4.28E-08	0.00	1.86E+11	114.3304	45163.	0.00
34.5600	-0.01093	18000.	-2062.	5.77E-07	0.00	1.86E+11	116.0143	45835.	0.00
34.9200	-0.01093	10175.	-1557.	9.04E-07	0.00	1.86E+11	117.6783	46507.	0.00
35.2800	-0.01093	4546.	-1045.	1.08E-06	0.00	1.86E+11	119.3300	47179.	0.00
35.6400	-0.01092	1144.	-526.1614	1.14E-06	0.00	1.86E+11	120.9754	47850.	0.00
36.0000	-0.01092	0.00	0.00	1.15E-06	0.00	1.86E+11	122.6179	24261.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection	=	1.00360143 inches
Computed slope at pile head	=	-0.00530188 radians
Maximum bending moment	=	1823063. inch-lbs
Maximum shear force	=	19761. lbs

Section A - Slope Stability Pile - Sta 8263+00.l p11o

Depth of maximum bending moment = 16.92000000 feet below pile head

Depth of maximum shear force = 10.44000000 feet below pile head

Number of iterations = 270

Number of zero deflection points = 1

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

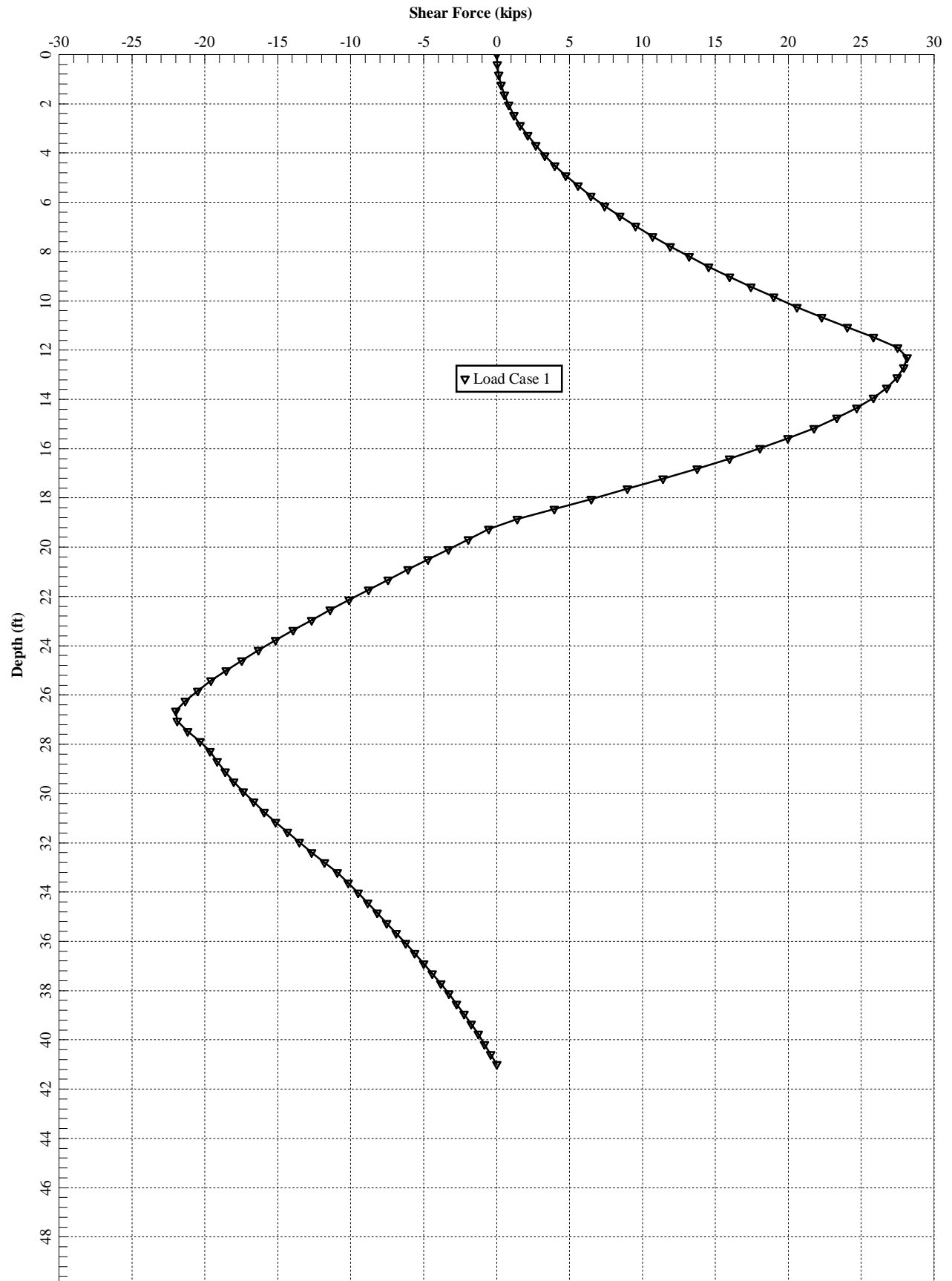
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.0036	-0.00530	19761.	1823063.

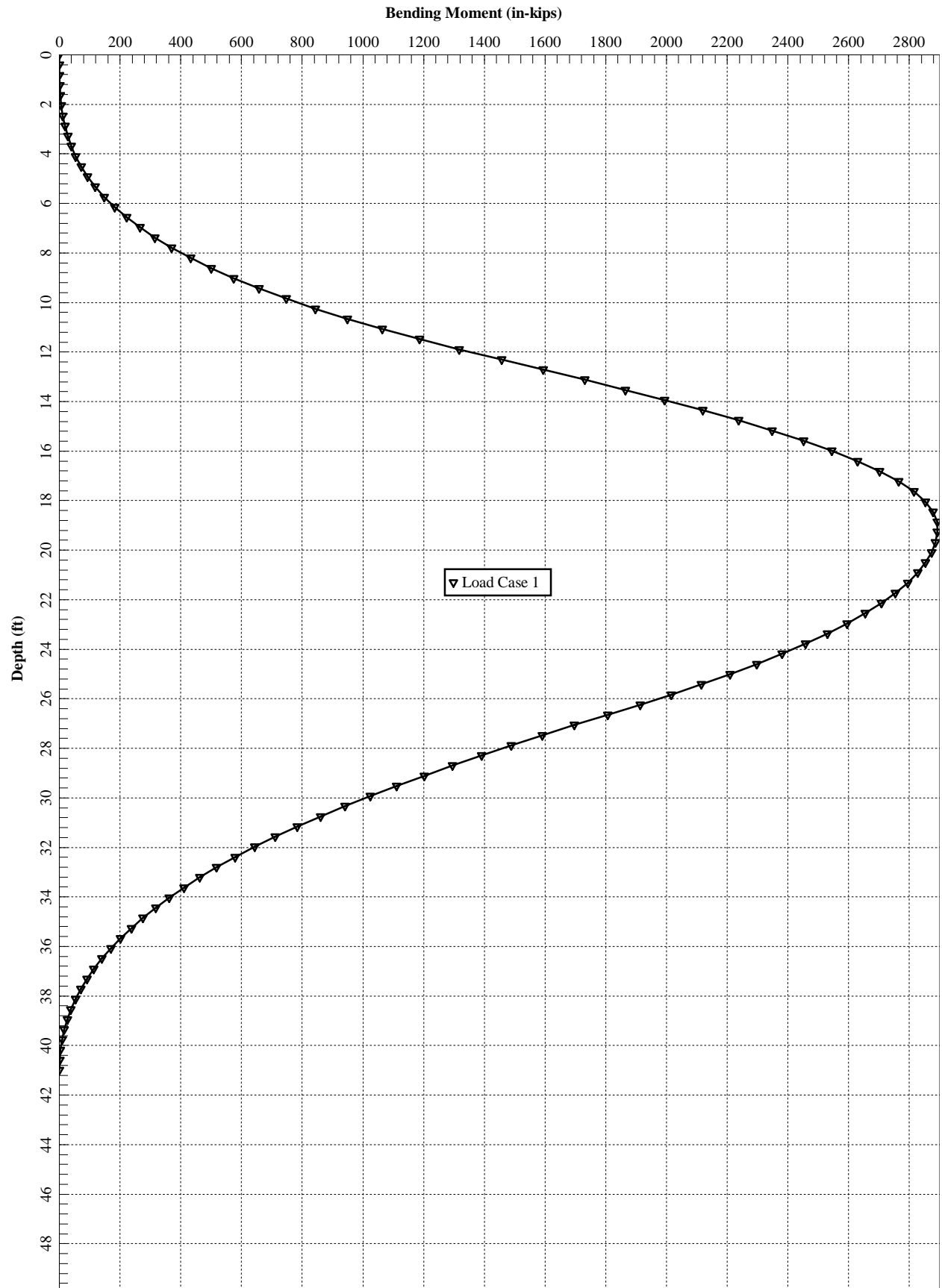
Maximum pile-head deflection = 1.0036014251 inches
Maximum pile-head rotation = -0.0053018803 radians = -0.303775 deg.

The analysis ended normally.

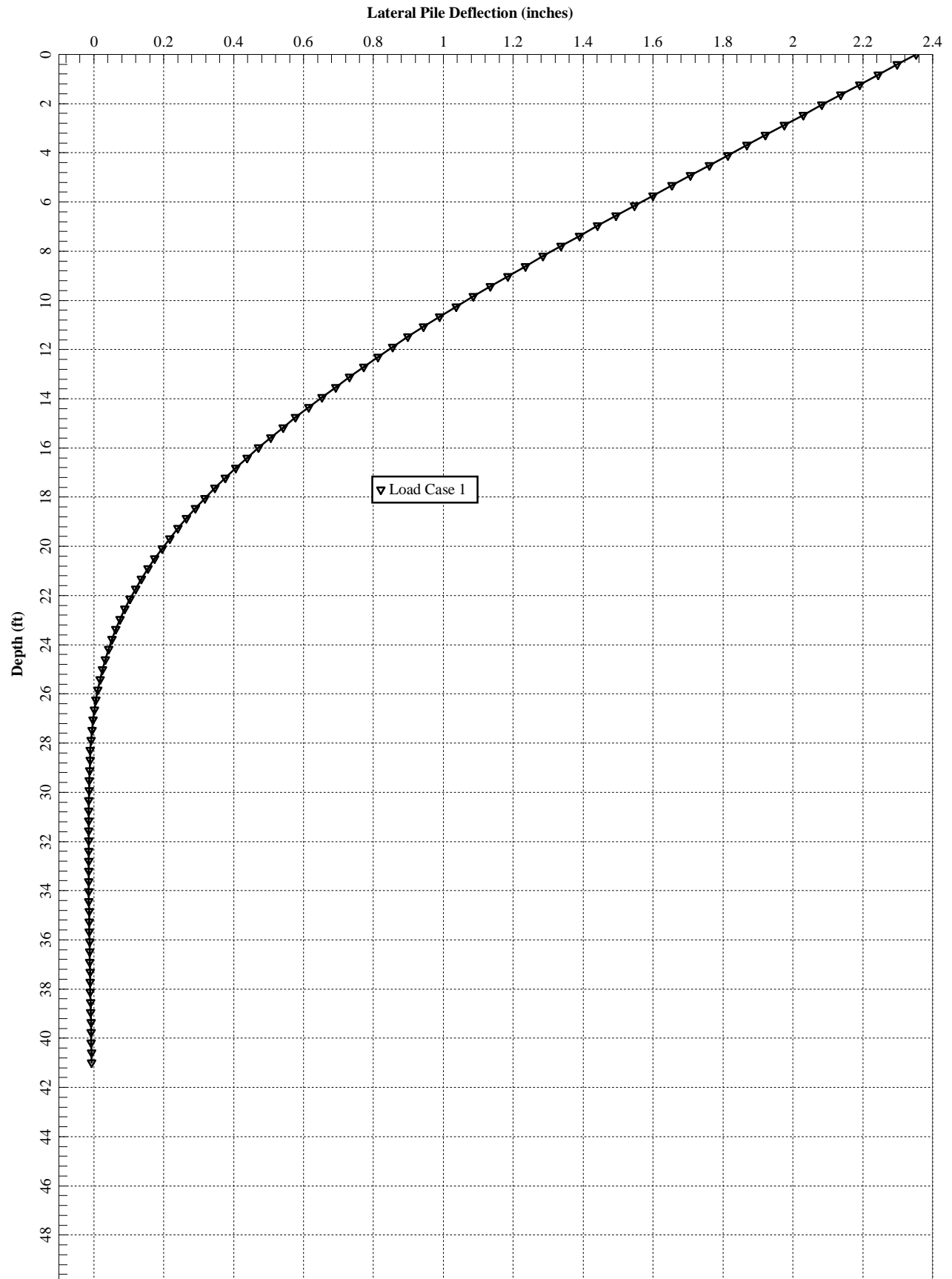
RW-13 Station 8264+00 - Service Load Case



RW-13 Station 8264+00 - Service Load Case



RW-13 Station 8264+00 - Service Load Case



LPile for Windows, Version 2019-11.002

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\\Users\\asgarden\\Desktop\\WFH\\Arkendale\\Stability Pile\\

Name of input data file:
Section A - Slope Stability Pile - Sta 8264+00.lp11

Name of output report file:
Section A - Slope Stability Pile - Sta 8264+00.lp11

Name of plot output file:
Section A - Slope Stability Pile - Sta 8264+00.lp11

Name of runtime message file:
Section A - Slope Stability Pile - Sta 8264+00.lp11

Date and Time of Analysis

Date: June 9, 2020

Time: 10:13:21

Problem Title

Project Name: Arkendale to Powells Creek Third Track Project, RW-13

Job Number: 15184

Client: STV, Inc.

Engineer: FM

Description: Retaining Wall 13 Soldier Pile Wall

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 100 |

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- Analysis includes loading by one distributed lateral load acting on pile
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 41.000 ft
Depth of ground surface below top of pile = 12.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.5800
2	12.000	14.5800
3	12.000	30.0000
4	41.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong H-Pile
Length of section = 12.000000 ft
Flange Width = 14.580000 in
Section Depth = 13.610000 in
Flange Thickness = 0.505000 in
Web Thickness = 0.505000 in
Section Area = 21.088800 sq. in
Moment of Inertia = 716.751440 in^4

Elastic Modulus

=

Section A - Slope Stability Pile - Sta 8264+00.1p11o
29000000. psi

Pile Section No. 2:

Section 2 is a drilled shaft with casing and H section core/insert

Length of section

=

29.000000 ft

Section Diameter

=

30.000000 in

Shear capacity of section

=

0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle

=

0.000 degrees

=

0.000 radians

Pile Batter Angle

=

0.000 degrees

=

0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer

=

12.000000 ft

Distance from top of pile to bottom of layer

=

19.000000 ft

Effective unit weight at top of layer

=

62.600000 pcf

Effective unit weight at bottom of layer

=

62.600000 pcf

Friction angle at top of layer

=

35.000000 deg.

Friction angle at bottom of layer

=

35.000000 deg.

Subgrade k at top of layer

=

60.000000 pci

Subgrade k at bottom of layer

=

60.000000 pci

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer

=

19.000000 ft

Distance from top of pile to bottom of layer

=

28.000000 ft

Effective unit weight at top of layer

=

62.600000 pcf

Effective unit weight at bottom of layer

=

62.600000 pcf

Undrained cohesion at top of layer

=

1000.000000 psf

Undrained cohesion at bottom of layer

=

1000.000000 psf

Section A - Slope Stability Pile - Sta 8264+00.1 p110

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	28.000000	ft
Distance from top of pile to bottom of layer	=	33.500000	ft
Effective unit weight at top of layer	=	62.600000	pcf
Effective unit weight at bottom of layer	=	62.600000	pcf
Friction angle at top of layer	=	35.000000	deg.
Friction angle at bottom of layer	=	35.000000	deg.
Subgrade k at top of layer	=	60.000000	pci
Subgrade k at bottom of layer	=	60.000000	pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	33.500000	ft
Distance from top of pile to bottom of layer	=	60.000000	ft
Effective unit weight at top of layer	=	57.600000	pcf
Effective unit weight at bottom of layer	=	57.600000	pcf
Friction angle at top of layer	=	23.000000	deg.
Friction angle at bottom of layer	=	23.000000	deg.
Subgrade k at top of layer	=	45.000000	pci
Subgrade k at bottom of layer	=	45.000000	pci

(Depth of the lowest soil layer extends 19.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	E50 or krm	kpy pci
1	Sand	12.0000	62.6000	--	35.0000	--	60.0000
	(Reese, et al.)	19.0000	62.6000	--	35.0000	--	60.0000
2	Stiff Clay	19.0000	62.6000	1000.0000	--	0.01000	--
	w/o Free Water	28.0000	62.6000	1000.0000	--	0.01000	--
3	Sand	28.0000	62.6000	--	35.0000	--	60.0000
	(Reese, et al.)	33.5000	62.6000	--	35.0000	--	60.0000
4	Sand	33.5000	57.6000	--	23.0000	--	45.0000
	(Reese, et al.)	60.0000	57.6000	--	23.0000	--	45.0000

Section A - Slope Stability Pile - Sta 8264+00.l p11o

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	12.000	0.8000	1.0000
2	60.000	0.8000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	0.000
2	144.000	392.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	No	Yes

Section A - Slope Stability Pile - Sta 8264+00.lp11o

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and H Strong Axis Core/Insert:

Length of Section	=	29.000000 ft
Outside Diameter of Casing	=	30.000000 in
Concrete Cover Thickness Inside Casing	=	3.000000 in
Casing Wall Thickness	=	0.0000 in
Moment of Inertia of Steel Casing	=	0.0000 in^4
Width Flange of Core/Insert	=	14.580000 in
Depth of Core/Insert	=	13.610000 in
Flange Thickness of Core/Insert	=	0.505000 in
Web Thickness of Core/Insert	=	0.505000 in
Moment of Inertia of Steel Core/Insert	=	716.751440 in^4
Yield Stress of Casing	=	36000. psi
Elastic Modulus of Casing	=	29000000. psi
Yield Stress of Core/Insert	=	50000. psi
Elastic Modulus of Core/Insert	=	29000000. psi
Number of Reinforcing Bars	=	12 bars
Area of Single Reinforcing Bar	=	0.0000 sq. in.
Area of All Reinforcing Bars	=	0.0000 sq. in.
Edge-to-Edge Bar Spacing	=	6.211657 in

		Section A - Slope Stability Pile - Sta 8264+00.Lp11o
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	8.28
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	706.858347 sq. in.
Area of Concrete	=	685.769547 sq. in.
Cross-sectional Area of Steel Casing	=	0.0000 sq. in.
Cross-sectional Area of Steel Core/Insert	=	21.088800 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	21.088800 sq. in.
Area Ratio of All Steel to Gross Area	=	2.98 percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	3386.056 kips
Tensile Load for Cracking of Concrete	=	-355.776 kips
Nominal Axial Tensile Capacity	=	-1054.440 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----
1	0.0000	0.0000	12.000000	0.00000
2	0.0000	0.0000	10.392305	6.000000
3	0.0000	0.0000	6.000000	10.392305
4	0.0000	0.0000	0.000000	12.000000
5	0.0000	0.0000	-6.000000	10.392305
6	0.0000	0.0000	-10.392305	6.000000
7	0.0000	0.0000	-12.000000	0.00000
8	0.0000	0.0000	-10.392305	-6.000000
9	0.0000	0.0000	-6.000000	-10.392305
10	0.0000	0.0000	0.000000	-12.000000
11	0.0000	0.0000	6.000000	-10.392305
12	0.0000	0.0000	10.392305	-6.000000

NOTE: The positions of the above rebars were computed by LPILE

Minimum spacing between any two bars not equal to zero = 6.212 inches
between bars 9 and 10.

Ratio of bar spacing to maximum aggregate size = 8.28

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Concrete Properties:

Compressive Strength of Concrete = 4000. psi
Modulus of Elasticity of Concrete = 3604997. psi
Modulus of Rupture of Concrete = -474.341649 psi
Compression Strain at Peak Stress = 0.001886
Tensile Strain at Fracture of Concrete = -0.0001154
Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Max Core Stress ksi	Run Msg
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	---
0.00000125	232.4085198	185926816.	15.0000000	0.00001875	-0.00001875	0.0783394	0.00000	0.00000	0.2446875	
0.00000250	463.4099867	185363995.	15.0000000	0.00003750	-0.00003750	0.1559041	0.00000	0.00000	0.4893750	
0.00000375	693.0044009	184801174.	15.0000000	0.00005625	-0.00005625	0.2326940	0.00000	0.00000	0.7340625	
0.00000500	921.1917623	184238352.	15.0000000	0.00007500	-0.00007500	0.3087091	0.00000	0.00000	0.9787500	
0.00000625	1148.	183675531.	15.0000000	0.00009375	-0.00009375	0.3839496	0.00000	0.00000	1.2234375	
0.00000750	1373.	183112710.	15.0000000	0.0001125	-0.0001125	0.4584153	0.00000	0.00000	1.4681250	
0.00000875	1373.	156953752.	9.6708280	0.00008462	-0.0001779	0.3455182	0.00000	0.00000	-3.0650901	C

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0.00001000	1373.	137334533.	9.6753056	0.00009675	-0.0002032	0.3937844	0.00000	0.00000	-3.5016613 C
0.00001125	1373.	122075140.	9.6797974	0.0001089	-0.0002286	0.4417752	0.00000	0.00000	-3.9379036 C
0.00001250	1373.	109867626.	9.6843036	0.0001211	-0.0002539	0.4894898	0.00000	0.00000	-4.3738149 C
0.00001375	1373.	99879660.	9.6888241	0.0001332	-0.0002793	0.5369276	0.00000	0.00000	-4.8093939 C
0.00001500	1373.	91556355.	9.6933591	0.0001454	-0.0003046	0.5840879	0.00000	0.00000	-5.2446387 C
0.00001625	1373.	84513559.	9.6979087	0.0001576	-0.0003299	0.6309699	0.00000	0.00000	-5.6795480 C
0.00001750	1373.	78476876.	9.7024730	0.0001698	-0.0003552	0.6775729	0.00000	0.00000	-6.1141199 C
0.00001875	1373.	73245084.	9.7070521	0.0001820	-0.0003805	0.7238961	0.00000	0.00000	-6.5483529 C
0.00002000	1373.	68667266.	9.7116460	0.0001942	-0.0004058	0.7699390	0.00000	0.00000	-6.9822452 C
0.00002125	1373.	64628015.	9.7162550	0.0002065	-0.0004310	0.8157006	0.00000	0.00000	-7.4157953 C
0.00002250	1373.	61037570.	9.7208790	0.0002187	-0.0004563	0.8611804	0.00000	0.00000	-7.8490014 C
0.00002375	1373.	57825066.	9.7255181	0.0002310	-0.0004815	0.9063775	0.00000	0.00000	-8.2818618 C
0.00002500	1405.	56192885.	9.7301726	0.0002433	-0.0005067	0.9512912	0.00000	0.00000	-8.7143748 C
0.00002625	1474.	56150509.	9.7348424	0.0002555	-0.0005320	0.9959207	0.00000	0.00000	-9.1465386 C
0.00002750	1543.	56108011.	9.7395277	0.0002678	-0.0005572	1.0402652	0.00000	0.00000	-9.5783516 C
0.00002875	1612.	56065390.	9.7442286	0.0002801	-0.0005824	1.0843241	0.00000	0.00000	-10.0098118 C
0.00003000	1681.	56022645.	9.7489452	0.0002925	-0.0006075	1.1280965	0.00000	0.00000	-10.4409176 C
0.00003125	1749.	55979792.	9.7535843	0.0003048	-0.0006327	1.1715713	0.00000	0.00000	-10.8717516 C
0.00003250	1818.	55936821.	9.7582118	0.0003171	-0.0006579	1.2147542	0.00000	0.00000	-11.3022602 C
0.00003375	1886.	55893727.	9.7628546	0.0003295	-0.0006830	1.2576473	0.00000	0.00000	-11.7324185 C
0.00003500	1955.	55850510.	9.7675126	0.0003419	-0.0007081	1.3002499	0.00000	0.00000	-12.1622246 C
0.00003625	2023.	55807168.	9.7721861	0.0003542	-0.0007333	1.3425612	0.00000	0.00000	-12.5916768 C
0.00003750	2091.	55763702.	9.7768750	0.0003666	-0.0007584	1.3845804	0.00000	0.00000	-13.0207733 C
0.00003875	2159.	55720110.	9.7815796	0.0003790	-0.0007835	1.4263066	0.00000	0.00000	-13.4495123 C
0.00004000	2227.	55676392.	9.7862999	0.0003915	-0.0008085	1.4677392	0.00000	0.00000	-13.8778919 C
0.00004125	2295.	55632547.	9.7910361	0.0004039	-0.0008336	1.5088772	0.00000	0.00000	-14.3059104 C
0.00004250	2363.	55588573.	9.7957882	0.0004163	-0.0008587	1.5497198	0.00000	0.00000	-14.7335659 C
0.00004375	2430.	55544470.	9.8005564	0.0004288	-0.0008837	1.5902663	0.00000	0.00000	-15.1608565 C
0.00004500	2498.	55500238.	9.8053407	0.0004412	-0.0009088	1.6305158	0.00000	0.00000	-15.5877803 C
0.00004625	2565.	55455875.	9.8101413	0.0004537	-0.0009338	1.6704675	0.00000	0.00000	-16.0143354 C
0.00004750	2632.	55411381.	9.8149583	0.0004662	-0.0009588	1.7101205	0.00000	0.00000	-16.4405198 C
0.00004875	2699.	55366755.	9.8197918	0.0004787	-0.0009838	1.7494740	0.00000	0.00000	-16.8663318 C
0.00005125	2833.	55277101.	9.8295087	0.0005038	-0.0010337	1.8272789	0.00000	0.00000	-17.7168300 C
0.00005375	2966.	55186909.	9.8392931	0.0005289	-0.0010836	1.9038755	0.00000	0.00000	-18.5658142 C
0.00005625	3099.	55096170.	9.8491458	0.0005540	-0.0011335	1.9792567	0.00000	0.00000	-19.4132682 C
0.00005875	3232.	55004877.	9.8590679	0.0005792	-0.0011833	2.0534153	0.00000	0.00000	-20.2591753 C
0.00006125	3363.	54913023.	9.8690604	0.0006045	-0.0012330	2.1263441	0.00000	0.00000	-21.1035188 C
0.00006375	3495.	54820600.	9.8791242	0.0006298	-0.0012827	2.1980357	0.00000	0.00000	-21.9462814 C
0.00006625	3626.	54727601.	9.8892605	0.0006552	-0.0013323	2.2684827	0.00000	0.00000	-22.7874456 C
0.00006875	3756.	54634017.	9.8994702	0.0006806	-0.0013819	2.3376774	0.00000	0.00000	-23.6269935 C
0.00007125	3886.	54539840.	9.9097546	0.0007061	-0.0014314	2.4056122	0.00000	0.00000	-24.4649069 C
0.00007375	4015.	54445063.	9.9201146	0.0007316	-0.0014809	2.4722791	0.00000	0.00000	-25.3011672 C
0.00007625	4144.	54349676.	9.9305515	0.0007572	-0.0015303	2.5376701	0.00000	0.00000	-26.1357553 C
0.00007875	4272.	54253671.	9.9410664	0.0007829	-0.0015796	2.6017771	0.00000	0.00000	-26.9686520 C
0.00008125	4400.	54157040.	9.9516604	0.0008086	-0.0016289	2.6645919	0.00000	0.00000	-27.7998374 C
0.00008375	4528.	54059773.	9.9623349	0.0008343	-0.0016782	2.7261061	0.00000	0.00000	-28.6292913 C
0.00008625	4654.	53961855.	9.9730911	0.0008602	-0.0017273	2.7863108	0.00000	0.00000	-29.4569955 C
0.00008875	4780.	53863288.	9.9839303	0.0008861	-0.0017764	2.8451977	0.00000	0.00000	-30.2829240 C
0.00009125	4906.	53764058.	9.9948537	0.0009120	-0.0018255	2.9027578	0.00000	0.00000	-31.1070578 C

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0.00009375	5031.	53664153.	10.0058627	0.0009380	-0.0018745	2.9589820	0.00000	0.00000	-31.9293749 C
0.00009625	5155.	53563564.	10.0169588	0.0009641	-0.0019234	3.0138612	0.00000	0.00000	-32.7498528 C
0.00009875	5279.	53462281.	10.0281432	0.0009903	-0.0019722	3.0673858	0.00000	0.00000	-33.5684687 C
0.0001013	5403.	53360292.	10.0394175	0.0010165	-0.0020210	3.1195465	0.00000	0.00000	-34.3851990 C
0.0001038	5525.	53257599.	10.0507614	0.0010428	-0.0020697	3.1703291	0.00000	0.00000	-35.2000851 C
0.0001063	5648.	53154365.	10.0619010	0.0010691	-0.0021184	3.2196689	0.00000	0.00000	-36.0139558 C
0.0001088	5769.	53050414.	10.0731300	0.0010955	-0.0021670	3.2676150	0.00000	0.00000	-36.8259298 C
0.0001113	5890.	52945737.	10.0844496	0.0011219	-0.0022156	3.3141574	0.00000	0.00000	-37.6359827 C
0.0001138	6011.	52840322.	10.0958616	0.0011484	-0.0022641	3.3592859	0.00000	0.00000	-38.4440898 C
0.0001163	6130.	52734156.	10.1073674	0.0011750	-0.0023125	3.4029901	0.00000	0.00000	-39.2502258 C
0.0001188	6249.	52627229.	10.1189687	0.0012016	-0.0023609	3.4452594	0.00000	0.00000	-40.0543648 C
0.0001213	6368.	52519528.	10.1306670	0.0012283	-0.0024092	3.4860829	0.00000	0.00000	-40.8564802 C
0.0001238	6486.	52411041.	10.1424641	0.0012551	-0.0024574	3.5254497	0.00000	0.00000	-41.6565450 C
0.0001263	6603.	52301754.	10.1543617	0.0012820	-0.0025055	3.5633485	0.00000	0.00000	-42.4545312 C
0.0001288	6720.	52191655.	10.1663616	0.0013089	-0.0025536	3.5997678	0.00000	0.00000	-43.2504103 C
0.0001313	6836.	52080729.	10.1784656	0.0013359	-0.0026016	3.6346959	0.00000	0.00000	-44.0441533 C
0.0001338	6951.	51968964.	10.1906755	0.0013630	-0.0026495	3.6681207	0.00000	0.00000	-44.8357302 C
0.0001363	7065.	51856345.	10.2029933	0.0013902	-0.0026973	3.7000302	0.00000	0.00000	-45.6251103 C
0.0001388	7179.	51742857.	10.2154210	0.0014174	-0.0027451	3.7304118	0.00000	0.00000	-46.4122622 C
0.0001413	7293.	51628485.	10.2279606	0.0014447	-0.0027928	3.7592527	0.00000	0.00000	-47.1971537 C
0.0001438	7405.	51513214.	10.2406143	0.0014721	-0.0028404	3.7865398	0.00000	0.00000	-47.9797517 C
0.0001463	7517.	51397028.	10.2533840	0.0014996	-0.0028879	3.8122600	0.00000	0.00000	-48.7600223 C
0.0001488	7628.	51279910.	10.2662721	0.0015271	-0.0029354	3.8363994	0.00000	0.00000	-49.5379308 C
0.0001588	7894.	49724658.	10.2299115	0.0016240	-0.0031385	3.9079886	0.00000	0.00000	-50.0000000 CY
0.0001688	8027.	47569183.	10.1400274	0.0017111	-0.0033514	3.9548268	0.00000	0.00000	-50.0000000 CY
0.0001788	8143.	45555913.	10.0573242	0.0017977	-0.0035648	3.9850450	0.00000	0.00000	-50.0000000 CY
0.0001888	8243.	43671738.	9.9785181	0.0018834	-0.0037791	3.9989100	0.00000	0.00000	-50.0000000 CY
0.0001988	8330.	41910675.	9.9061627	0.0019688	-0.0039937	3.9999471	0.00000	0.00000	-50.0000000 CY
0.0002088	8405.	40264199.	9.8405939	0.0020542	-0.0042083	3.9970490	0.00000	0.00000	-50.0000000 CY
0.0002188	8470.	38721586.	9.7809842	0.0021396	-0.0044229	3.9980175	0.00000	0.00000	-50.0000000 CY
0.0002288	8527.	37277344.	9.7260586	0.0022248	-0.0046377	3.9983012	0.00000	0.00000	-50.0000000 CY
0.0002388	8576.	35920642.	9.6745177	0.0023098	-0.0048527	3.9980129	0.00000	0.00000	-50.0000000 CY
0.0002488	8619.	34648028.	9.6276066	0.0023949	-0.0050676	3.9970654	0.00000	0.00000	-50.0000000 CY
0.0002588	8656.	33453186.	9.5848574	0.0024801	-0.0052824	3.9963558	0.00000	0.00000	-50.0000000 CY
0.0002688	8689.	32329895.	9.5458574	0.0025654	-0.0054971	3.9999577	0.00000	0.00000	-50.0000000 CY
0.0002788	8717.	31272392.	9.5103356	0.0026510	-0.0057115	3.9990082	0.00000	0.00000	-50.0000000 CY
0.0002888	8742.	30276308.	9.4778694	0.0027367	-0.0059258	3.9960735	0.00000	0.00000	-50.0000000 CY
0.0002988	8764.	29335160.	9.4475925	0.0028225	-0.0061400	3.9999734	0.00000	0.00000	-50.0000000 CY
0.0003088	8782.	28445118.	9.4185276	0.0029080	-0.0063545	3.9978739	0.00000	0.00000	-50.0000000 CY
0.0003188	8799.	27604509.	9.3918112	0.0029936	-0.0065689	3.9975917	0.00000	0.00000	-50.0000000 CY
0.0003288	8813.	26807430.	9.3671794	0.0030795	-0.0067830	3.9982350	0.00000	0.00000	-50.0000000 CY
0.0003388	8825.	26051940.	9.3442502	0.0031654	-0.0069971	3.9972468	0.00000	0.00000	-50.0000000 CY
0.0003488	8836.	25335347.	9.3235219	0.0032516	-0.0072109	3.9975028	0.00000	0.00000	-50.0000000 CY
0.0003588	8844.	24653533.	9.3037208	0.0033377	-0.0074248	3.9999975	0.00000	0.00000	-50.0000000 CY
0.0003688	8852.	24005723.	9.2861265	0.0034243	-0.0076382	3.9950919	0.00000	0.00000	-50.0000000 CY
0.0003788	8858.	23387790.	9.2691598	0.0035107	-0.0078518	3.9993981	0.00000	0.00000	-50.0000000 CY
0.0003888	8863.	22799698.	9.2539068	0.0035975	-0.0080650	3.9936911	0.00000	0.00000	-50.0000000 CY
0.0003988	8867.	22237692.	9.2395415	0.0036843	-0.0082782	3.9964503	0.00000	0.00000	-50.0000000 CY
0.0004088	8870.	21701411.	9.2261763	0.0037712	-0.0084913	3.9997208	0.00000	0.00000	-50.0000000 CY

0.00041888870.21183169.9.2340098Section A - Slope Stability Pile - Sta 8264+00.1p11o0.0038667-0.00869583.99041380.000000.000000-50.0000000 CY

Summary of Results for Nominal Moment Capacity for Section 2

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	0.000	8799.975	0.00300000

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	8800.	0.0000	5720.	53092521.
1	0.75	8800.	0.0000	6600.	52304658.
1	0.90	8800.	0.0000	7920.	49301858.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head	Equivalent Top Depth Below Grnd Surf	Same Layer Type As Layer	Layer is Rock or is Below	F0 Integral for Layer	F1 Integral for Layer
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	ft	ft	Above	Rock Layer	lbs	lbs
1	12.0000	0.00	N. A.	No	0.00	51235.
2	19.0000	5.5050	No	No	51235.	126615.
3	28.0000	12.8018	No	No	177850.	259764.
4	33.5000	26.3379	Yes	No	437614.	N. A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi *	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	2.3520	4.96E-06	0.00	-0.01094	5.04E-08	2.08E+10	0.00	0.00	3.3483
0.4100	2.2982	40.5255	41.1845	-0.01094	0.4122	2.08E+10	0.00	0.00	13.3933
0.8200	2.2444	405.2555	140.0273	-0.01094	4.1218	2.08E+10	0.00	0.00	26.7867
1.2300	2.1905	1418.	304.7653	-0.01094	14.4263	2.08E+10	0.00	0.00	40.1800
1.6400	2.1367	3404.	535.3985	-0.01094	34.6232	2.08E+10	0.00	0.00	53.5733
2.0500	2.0829	6687.	831.9269	-0.01094	68.0098	2.08E+10	0.00	0.00	66.9667
2.4600	2.0291	11590.	1194.	-0.01094	117.8837	2.08E+10	0.00	0.00	80.3600
2.8700	1.9753	18439.	1623.	-0.01093	187.5423	2.08E+10	0.00	0.00	93.7533
3.2800	1.9215	27557.	2117.	-0.01093	280.2830	2.08E+10	0.00	0.00	107.1467
3.6900	1.8678	39269.	2677.	-0.01092	399.4033	2.08E+10	0.00	0.00	120.5400
4.1000	1.8141	53899.	3303.	-0.01091	548.2006	2.08E+10	0.00	0.00	133.9333
4.5100	1.7605	71771.	3995.	-0.01089	729.9724	2.08E+10	0.00	0.00	147.3267
4.9200	1.7069	93209.	4753.	-0.01087	948.0160	2.08E+10	0.00	0.00	160.7200
5.3300	1.6535	118537.	5576.	-0.01085	1206.	2.08E+10	0.00	0.00	174.1133
5.7400	1.6002	148080.	6466.	-0.01082	1506.	2.08E+10	0.00	0.00	187.5067
6.1500	1.5470	182162.	7421.	-0.01078	1853.	2.08E+10	0.00	0.00	200.9000
6.5600	1.4941	221107.	8443.	-0.01073	2249.	2.08E+10	0.00	0.00	214.2933
6.9700	1.4415	265240.	9530.	-0.01067	2698.	2.08E+10	0.00	0.00	227.6867

Section A - Slope Stability Pile - Sta 8264+00.1p11o									
7. 3800	1. 3891	314884.	10683.	-0. 01060	3203.	2. 08E+10	0. 00	0. 00	241. 0800
7. 7900	1. 3371	370363.	11902.	-0. 01052	3767.	2. 08E+10	0. 00	0. 00	254. 4733
8. 2000	1. 2856	432002.	13187.	-0. 01043	4394.	2. 08E+10	0. 00	0. 00	267. 8667
8. 6100	1. 2345	500126.	14538.	-0. 01032	5087.	2. 08E+10	0. 00	0. 00	281. 2600
9. 0200	1. 1840	575058.	15955.	-0. 01019	5849.	2. 08E+10	0. 00	0. 00	294. 6533
9. 4300	1. 1342	657122.	17438.	-0. 01004	6684.	2. 08E+10	0. 00	0. 00	308. 0467
9. 8400	1. 0852	746643.	18986.	-0. 00988	7594.	2. 08E+10	0. 00	0. 00	321. 4400
10. 2500	1. 0370	843945.	20600.	-0. 00969	8584.	2. 08E+10	0. 00	0. 00	334. 8333
10. 6600	0. 9899	949351.	22281.	-0. 00948	9656.	2. 08E+10	0. 00	0. 00	348. 2267
11. 0700	0. 9438	1063188.	24027.	-0. 00924	10814.	2. 08E+10	0. 00	0. 00	361. 6200
11. 4800	0. 8990	1185778.	25839.	-0. 00897	12060.	2. 08E+10	0. 00	0. 00	375. 0133
11. 8900	0. 8555	1317445.	27493.	-0. 00868	13400.	2. 08E+10	0. 00	0. 00	297. 2179
12. 3000	0. 8136	1456307.	28154.	-0. 00846	0. 00	5. 62E+10	-28. 4451	172. 0178	0. 00
12. 7100	0. 7723	1594481.	27909.	-0. 00832	0. 00	5. 61E+10	-71. 1952	453. 5647	0. 00
13. 1200	0. 7317	1730931.	27446.	-0. 00818	0. 00	5. 60E+10	-116. 8225	785. 5475	0. 00
13. 5300	0. 6918	1864553.	26756.	-0. 00802	0. 00	5. 59E+10	-163. 7751	1165.	0. 00
13. 9400	0. 6528	1994211.	25835.	-0. 00785	0. 00	5. 58E+10	-210. 6396	1588.	0. 00
14. 3500	0. 6146	2118770.	24687.	-0. 00767	0. 00	5. 57E+10	-256. 0149	2050.	0. 00
14. 7600	0. 5773	2237132.	23321.	-0. 00748	0. 00	5. 57E+10	-299. 4257	2552.	0. 00
15. 1700	0. 5410	2348246.	21748.	-0. 00727	0. 00	5. 56E+10	-339. 8232	3090.	0. 00
15. 5800	0. 5058	2451134.	19988.	-0. 00706	0. 00	5. 55E+10	-375. 8179	3656.	0. 00
15. 9900	0. 4716	2544924.	18056.	-0. 00684	0. 00	5. 55E+10	-409. 5154	4273.	0. 00
16. 4000	0. 4385	2628802.	15966.	-0. 00661	0. 00	5. 54E+10	-439. 9891	4937.	0. 00
16. 8100	0. 4065	2702030.	13741.	-0. 00637	0. 00	5. 54E+10	-464. 4131	5621.	0. 00
17. 2200	0. 3758	2764015.	11406.	-0. 00613	0. 00	5. 53E+10	-484. 7499	6347.	0. 00
17. 6300	0. 3462	2814267.	8981.	-0. 00588	0. 00	5. 53E+10	-500. 9342	7119.	0. 00
18. 0400	0. 3179	2852392.	6494.	-0. 00563	0. 00	5. 53E+10	-510. 3433	7899.	0. 00
18. 4500	0. 2908	2878164.	3970.	-0. 00537	0. 00	5. 52E+10	-515. 5057	8721.	0. 00
18. 8600	0. 2650	2891458.	1432.	-0. 00512	0. 00	5. 52E+10	-516. 3657	9587.	0. 00
19. 2700	0. 2405	2892252.	-535. 2893	-0. 00486	0. 00	5. 52E+10	-283. 2173	5795.	0. 00
19. 6800	0. 2172	2886191.	-1927.	-0. 00460	0. 00	5. 52E+10	-282. 6818	6404.	0. 00
20. 0900	0. 1952	2873287.	-3316.	-0. 00435	0. 00	5. 52E+10	-281. 6385	7100.	0. 00
20. 5000	0. 1744	2853565.	-4697.	-0. 00409	0. 00	5. 53E+10	-280. 0645	7900.	0. 00
20. 9100	0. 1549	2827064.	-6070.	-0. 00384	0. 00	5. 53E+10	-277. 9335	8827.	0. 00
21. 3200	0. 1367	2793835.	-7431.	-0. 00359	0. 00	5. 53E+10	-275. 2148	9909.	0. 00
21. 7300	0. 1196	2753945.	-8777.	-0. 00334	0. 00	5. 53E+10	-271. 8719	11183.	0. 00
22. 1400	0. 1038	2707473.	-10104.	-0. 00310	0. 00	5. 54E+10	-267. 8611	12699.	0. 00
22. 5500	0. 08912	2654517.	-11411.	-0. 00286	0. 00	5. 54E+10	-263. 1283	14526.	0. 00
22. 9600	0. 07563	2595192.	-12692.	-0. 00263	0. 00	5. 54E+10	-257. 6051	16758.	0. 00
23. 3700	0. 06327	2529631.	-13943.	-0. 00240	0. 00	5. 55E+10	-251. 2032	19533.	0. 00
23. 7800	0. 05202	2457990.	-15161.	-0. 00218	0. 00	5. 55E+10	-243. 8035	23059.	0. 00
24. 1900	0. 04183	2380447.	-16339.	-0. 00196	0. 00	5. 56E+10	-235. 2402	27666.	0. 00
24. 6000	0. 03269	2297209.	-17472.	-0. 00176	0. 00	5. 56E+10	-225. 2691	33907.	0. 00
25. 0100	0. 02454	2208519.	-18552.	-0. 00156	0. 00	5. 57E+10	-213. 5062	42805.	0. 00
25. 4200	0. 01735	2114660.	-19567.	-0. 00137	0. 00	5. 57E+10	-199. 2880	56503.	0. 00
25. 8300	0. 01108	2015978.	-20503.	-0. 00119	0. 00	5. 58E+10	-181. 2911	80474.	0. 00
26. 2400	0. 00569	1912907.	-21333.	-0. 00101	0. 00	5. 59E+10	-156. 1028	135005.	0. 00
26. 6500	0. 00112	1806057.	-21978.	-8. 49E-04	0. 00	5. 59E+10	-105. 8472	463845.	0. 00
27. 0600	-0. 00266	1696645.	-21910.	-6. 95E-04	0. 00	5. 60E+10	133. 4533	246658.	0. 00

Section A - Slope Stability Pile - Sta 8264+00.1p11o									
27.4700	-0.00571	1590463.	-21178.	-5.50E-04	0.00	5.61E+10	164.1964	141395.	0.00
27.8800	-0.00808	1488257.	-20326.	-4.15E-04	0.00	5.61E+10	181.9435	110811.	0.00
28.2900	-0.00980	1390454.	-19652.	-2.90E-04	0.00	5.69E+10	91.9682	46165.	0.00
28.7000	-0.01093	1294877.	-19167.	-2.13E-04	0.00	1.83E+11	105.1713	47326.	0.00
29.1100	-0.01189	1201847.	-18620.	-1.79E-04	0.00	1.84E+11	117.2238	48488.	0.00
29.5200	-0.01270	1111654.	-18017.	-1.48E-04	0.00	1.84E+11	128.1303	49650.	0.00
29.9300	-0.01335	1024562.	-17362.	-1.20E-04	0.00	1.84E+11	137.9034	50812.	0.00
30.3400	-0.01387	940809.	-16662.	-9.34E-05	0.00	1.84E+11	146.5621	51974.	0.00
30.7500	-0.01427	860603.	-15923.	-6.93E-05	0.00	1.84E+11	154.1315	53136.	0.00
31.1600	-0.01456	784128.	-15148.	-4.74E-05	0.00	1.85E+11	160.6416	54298.	0.00
31.5700	-0.01474	711542.	-14345.	-2.74E-05	0.00	1.85E+11	166.1267	55460.	0.00
31.9800	-0.01483	642978.	-13516.	-9.41E-06	0.00	1.85E+11	170.6245	56622.	0.00
32.3900	-0.01483	578543.	-12668.	6.83E-06	0.00	1.85E+11	174.1755	57784.	0.00
32.8000	-0.01476	518325.	-11805.	2.14E-05	0.00	1.85E+11	176.8216	58946.	0.00
33.2100	-0.01462	462386.	-10930.	3.44E-05	0.00	1.85E+11	178.6063	60107.	0.00
33.6200	-0.01442	410772.	-10159.	4.60E-05	0.00	1.85E+11	134.6799	45952.	0.00
34.0300	-0.01417	362417.	-9497.	5.63E-05	0.00	1.86E+11	134.8241	46823.	0.00
34.4400	-0.01387	317326.	-8834.	6.53E-05	0.00	1.86E+11	134.4202	47695.	0.00
34.8500	-0.01352	275489.	-8175.	7.31E-05	0.00	1.86E+11	133.5013	48566.	0.00
35.2600	-0.01315	236883.	-7522.	7.99E-05	0.00	1.86E+11	132.1006	49438.	0.00
35.6700	-0.01274	201475.	-6876.	8.57E-05	0.00	1.86E+11	130.2507	50309.	0.00
36.0800	-0.01230	169220.	-6241.	9.06E-05	0.00	1.86E+11	127.9832	51181.	0.00
36.4900	-0.01185	140063.	-5618.	9.47E-05	0.00	1.86E+11	125.3285	52052.	0.00
36.9000	-0.01137	113940.	-5009.	9.81E-05	0.00	1.86E+11	122.3158	52923.	0.00
37.3100	-0.01088	90777.	-4415.	1.01E-04	0.00	1.86E+11	118.9726	53795.	0.00
37.7200	-0.01038	70495.	-3839.	1.03E-04	0.00	1.86E+11	115.3246	54666.	0.00
38.1300	-0.00987	53004.	-3281.	1.05E-04	0.00	1.86E+11	111.3951	55538.	0.00
38.5400	-0.00935	38209.	-2743.	1.06E-04	0.00	1.86E+11	107.2056	56409.	0.00
38.9500	-0.00883	26010.	-2227.	1.07E-04	0.00	1.86E+11	102.7747	57281.	0.00
39.3600	-0.00830	16298.	-1733.	1.07E-04	0.00	1.86E+11	98.1186	58152.	0.00
39.7700	-0.00777	8962.	-1262.	1.08E-04	0.00	1.86E+11	93.2506	59023.	0.00
40.1800	-0.00724	3882.	-815.4478	1.08E-04	0.00	1.86E+11	88.1812	59895.	0.00
40.5900	-0.00671	937.5813	-394.5437	1.08E-04	0.00	1.86E+11	82.9180	60766.	0.00
41.0000	-0.00618	0.00	0.00	1.08E-04	0.00	1.86E+11	77.4656	30819.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection	=	2.35201111 inches
Computed slope at pile head	=	-0.01093955 radians
Maximum bending moment	=	2892252. inch-lbs
Maximum shear force	=	28154. lbs

Section A - Slope Stability Pile - Sta 8264+00.l p11o

Depth of maximum bending moment = 19.27000000 feet below pile head

Depth of maximum shear force = 12.30000000 feet below pile head

Number of iterations = 69

Number of zero deflection points = 1

Summary of Pile-head Responses for Conventional Analyses

Defi nitions of Pile-head Loading Condi tions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	2.3520	-0.01094	28154.	2892252.

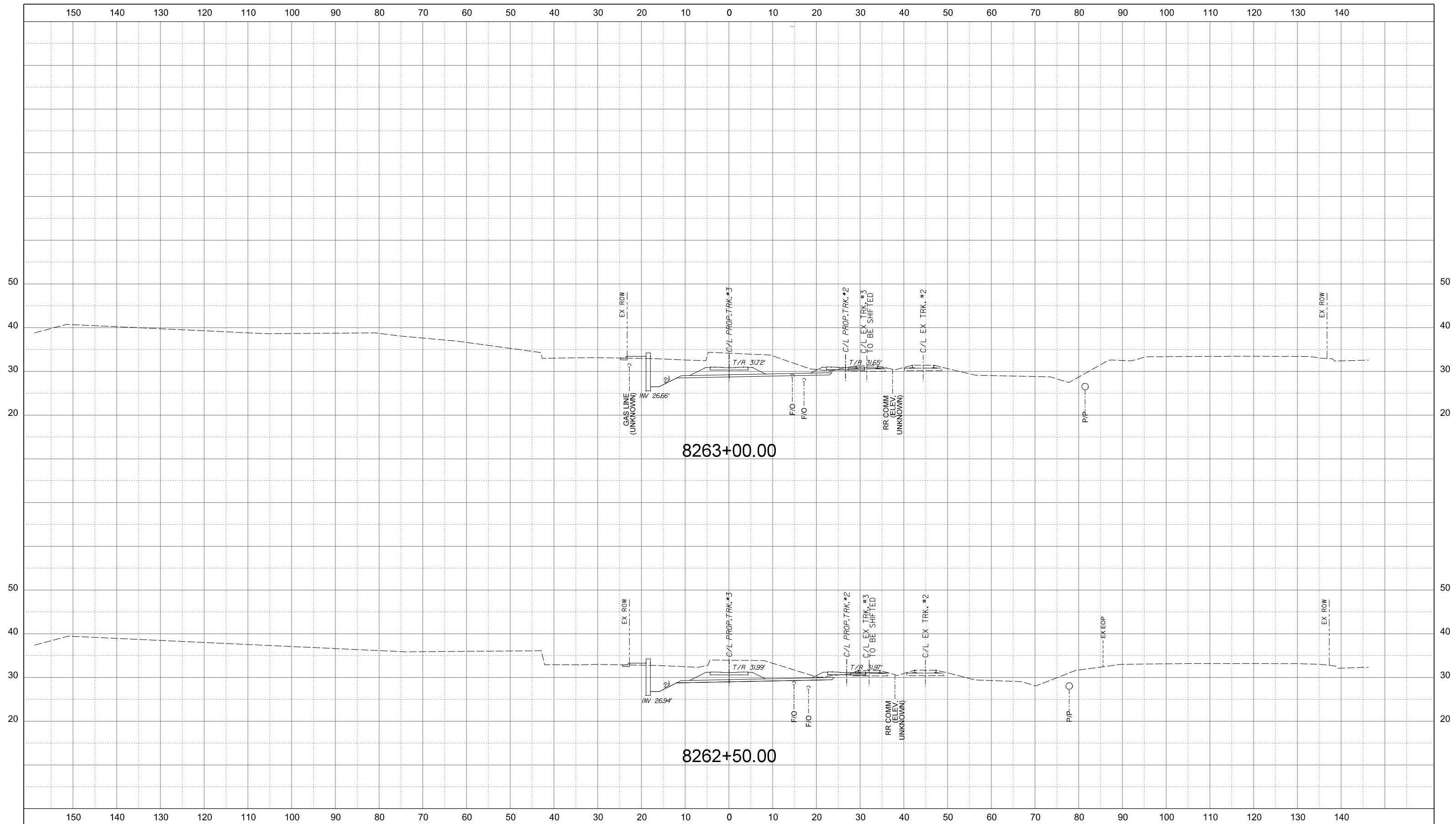
Maximum pile-head deflection = 2.3520111078 inches
Maximum pile-head rotation = -0.0109395465 radians = -0.626790 deg.

The analysis ended normally.

Appendix E

Wall Cross Sections

Proposed Wall Cross Sections (7 pages)



INVITATION FOR BID
NOT FOR CONSTRUCTION

NOTE:
1. ALL UTILITY LOCATIONS AND ELEVATIONS SHOWN ARE APPROXIMATE.
CONTRACTOR SHALL VERIFY UTILITY BEFORE CONSTRUCTION.
2. PROPOSED RELOCATED PLANTATION PIPELINE IS 30FT BELOW GRADE.

APPROVED BY VRE	REV.NO.	DATE	BY	APP BY	DESCRIPTION
	0	05/13/20			INVITATION FOR BID
APPROVED BY COUNTY					

DESIGNED BY:	KRJ
DRAWN BY:	KRJ
CHECKED BY:	RCB
DATE:	05/13/2020

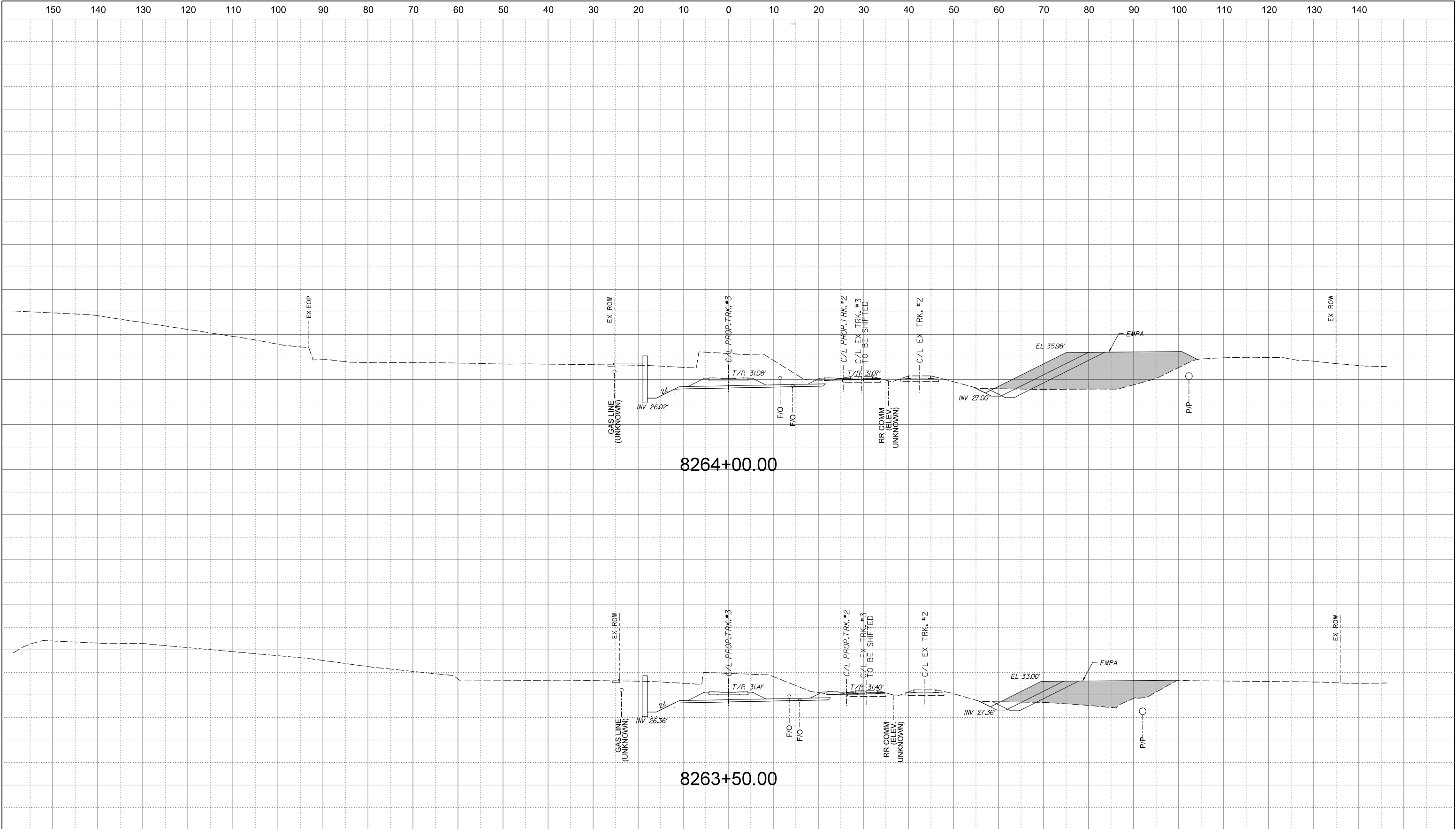


 STV Incorporated
2701 Prosperity Avenue, Suite 3
Fairfax, Virginia 22031

QUANTICO STATION

STA. 8262+50.00
TO
STA. 8263+00.00

IFB NO:	IFB-020-019
DRAWING NO:	XS-029
SCALE:	1" = 10'
SHEET NO:	OF



INVITATION FOR BID
NOT FOR CONSTRUCTION

NOTE:

1. ALL UTILITY LOCATIONS AND ELEVATIONS SHOWN ARE APPROXIMATE. CONTRACTOR SHALL VERIFY UTILITY BEFORE CONSTRUCTION.

2. PROPOSED RELOCATED PLANTATION PIPELINE IS 30FT BELOW GRADE.

APPROVED BY VRE	REV.NO.	DATE	BY	APP BY	DESCRIPTION
	0	05/13/20			INVITATION FOR BID
APPROVED BY COUNTY					

DESIGNED BY:
KRJ

DRAWN BY:
KRJ

CHECKED BY:
RCB

DATE:
05/13/2020

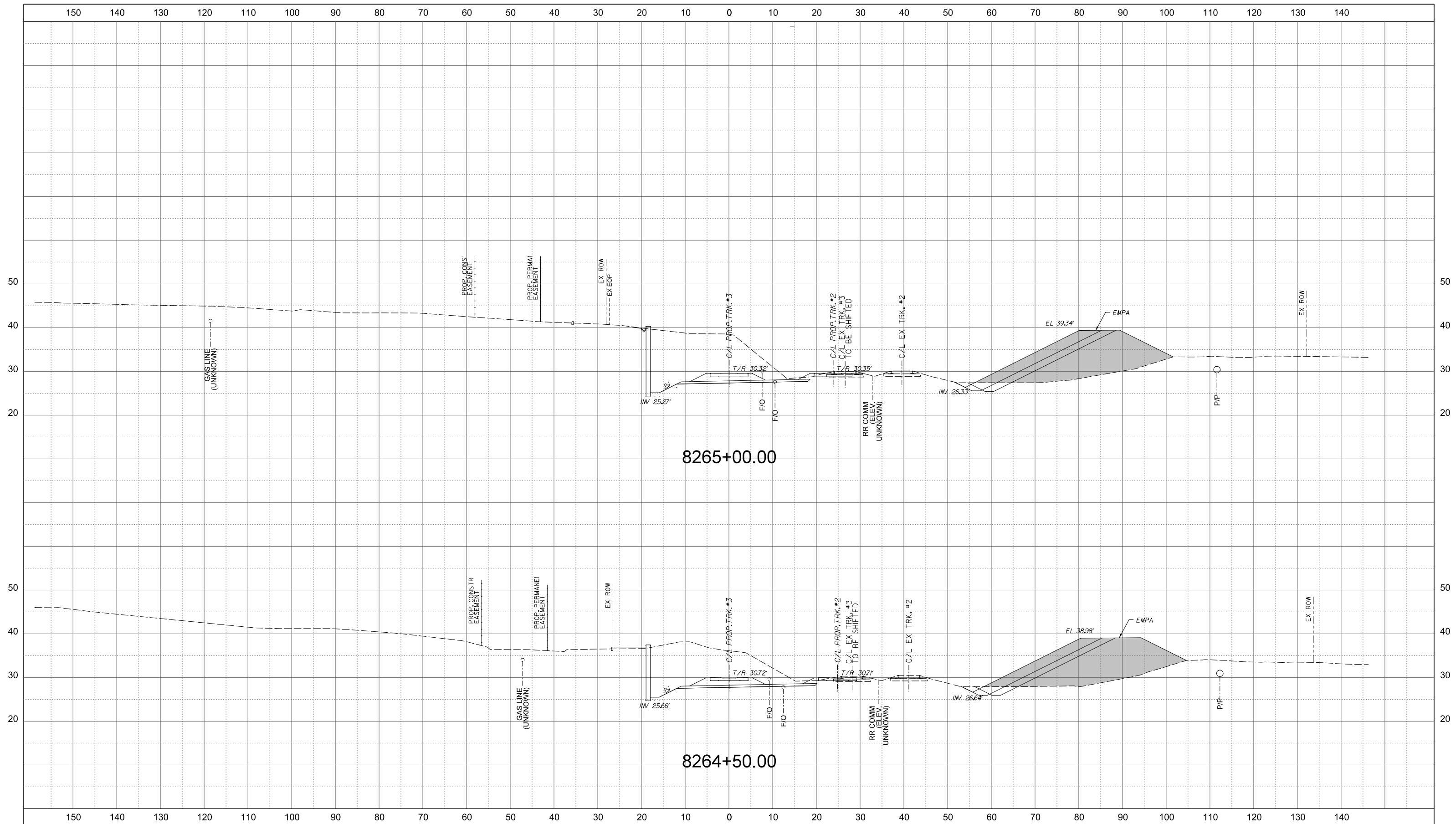
STV *100 Years*

STV Incorporated
2701 Prosperity Avenue, Suite 305
Fairfax, Virginia 22031

QUANTICO STATION

STA. 8263+50.00
TO
STA. 8264+00.00

IFB NO: IFB-020-019
DRAWING NO: XS-030
SCALE: 1" = 10'
SHEET NO: OF



INVITATION FOR BID
NOT FOR CONSTRUCTION

NOTE:
1. ALL UTILITY LOCATIONS AND ELEVATIONS SHOWN ARE APPROXIMATE.
CONTRACTOR SHALL VERIFY UTILITY BEFORE CONSTRUCTION.
2. PROPOSED RELOCATED PLANTATION PIPELINE IS 30FT BELOW GRADE.

APPROVED BY VRE	REV.NO.	DATE	BY	APP BY	DESCRIPTION
	0	05/13/20			INVITATION FOR BID
APPROVED BY COUNTY					

DESIGNED BY:	KRJ
DRAWN BY:	KRJ
CHECKED BY:	RCB
DATE:	05/13/2020

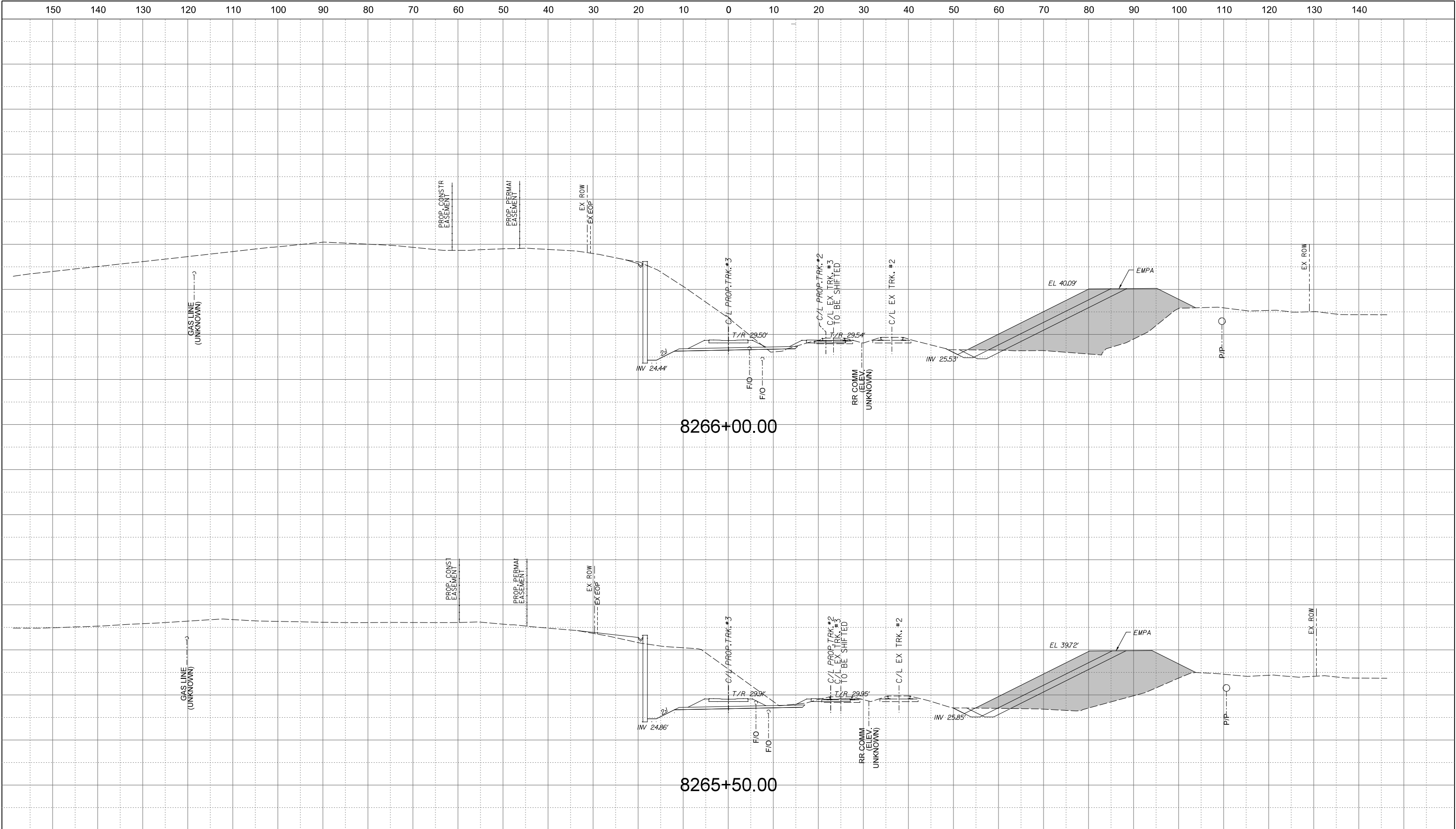


STV Incorporated
2701 Prosperity Avenue, Suite 305
Fairfax, Virginia 22031

QUANTICO STATION

STA. 8264+50.00
TO
STA. 8265+00.00

IFB NO:	IFB-020-019
DRAWING NO:	XS-031
SCALE:	1" = 10'
SHEET NO:	OF



INVITATION FOR BID
NOT FOR CONSTRUCTION

NOTE:

1. ALL UTILITY LOCATIONS AND ELEVATIONS SHOWN ARE APPROXIMATE. CONTRACTOR SHALL VERIFY UTILITY BEFORE CONSTRUCTION.

2. PROPOSED RELOCATED PLANTATION PIPELINE IS 30FT BELOW GRADE.

APPROVED BY VRE	REV.NO.	DATE	BY	APP BY	DESCRIPTION
	0	05/13/20			INVITATION FOR BID
APPROVED BY COUNTY					

DESIGNED BY:
KRJ

DRAWN BY:
KRJ

CHECKED BY:
RCB

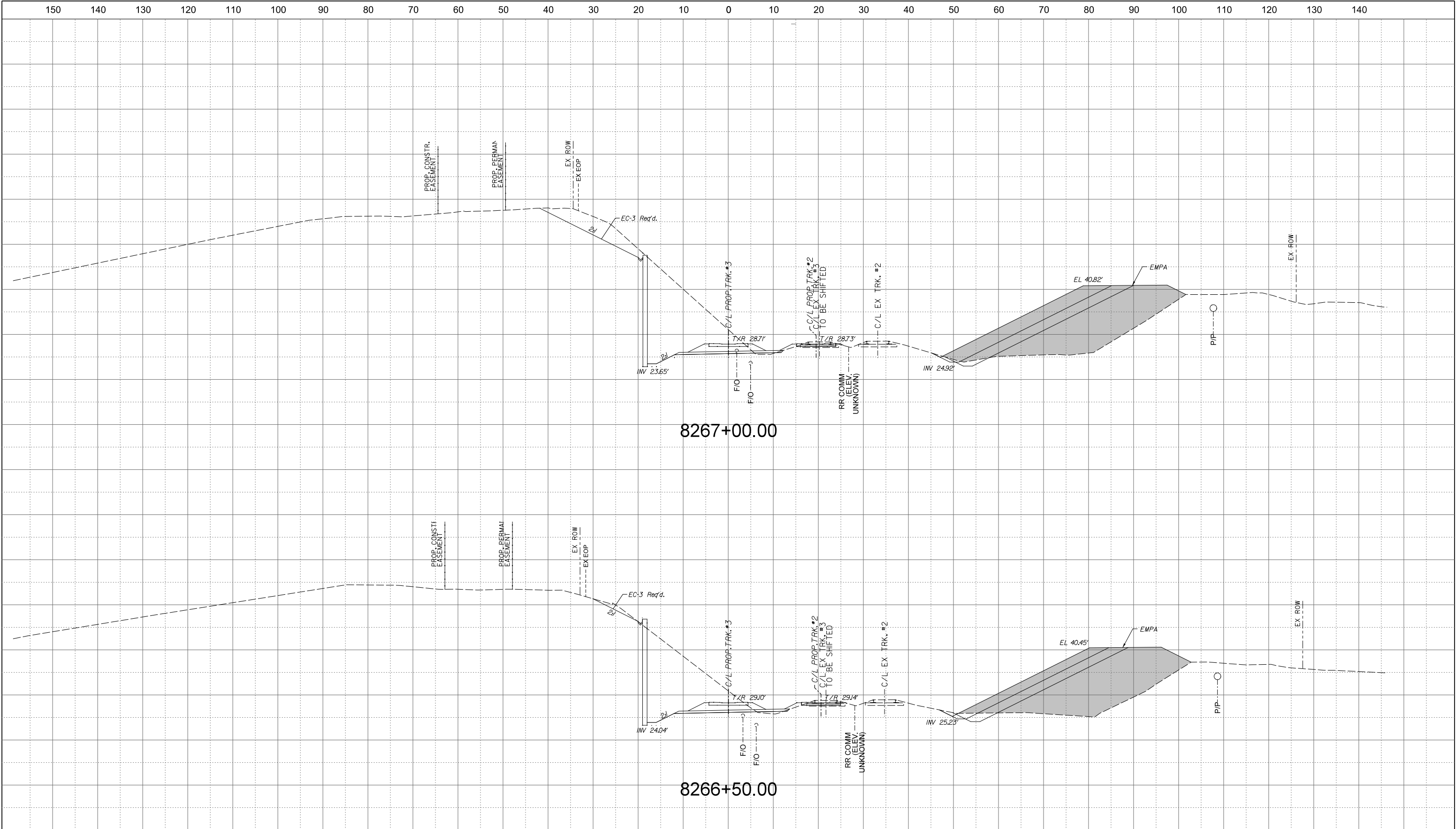
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05/13/2020

STV Incorporated
2701 Prosperity Avenue, Suite 305
Fairfax, Virginia 22031

QUANTICO STATION

STA. 8265+50.00
TO
STA. 8266+00.00

IFB NO: IFB-020-019
DRAWING NO: XS-032
SCALE: 1" = 10'
SHEET NO: OF



INVITATION FOR BID
NOT FOR CONSTRUCTION

NOTE:

1. ALL UTILITY LOCATIONS AND ELEVATIONS SHOWN ARE APPROXIMATE. CONTRACTOR SHALL VERIFY UTILITY BEFORE CONSTRUCTION.

2. PROPOSED RELOCATED PLANTATION PIPELINE IS 30FT BELOW GRADE.

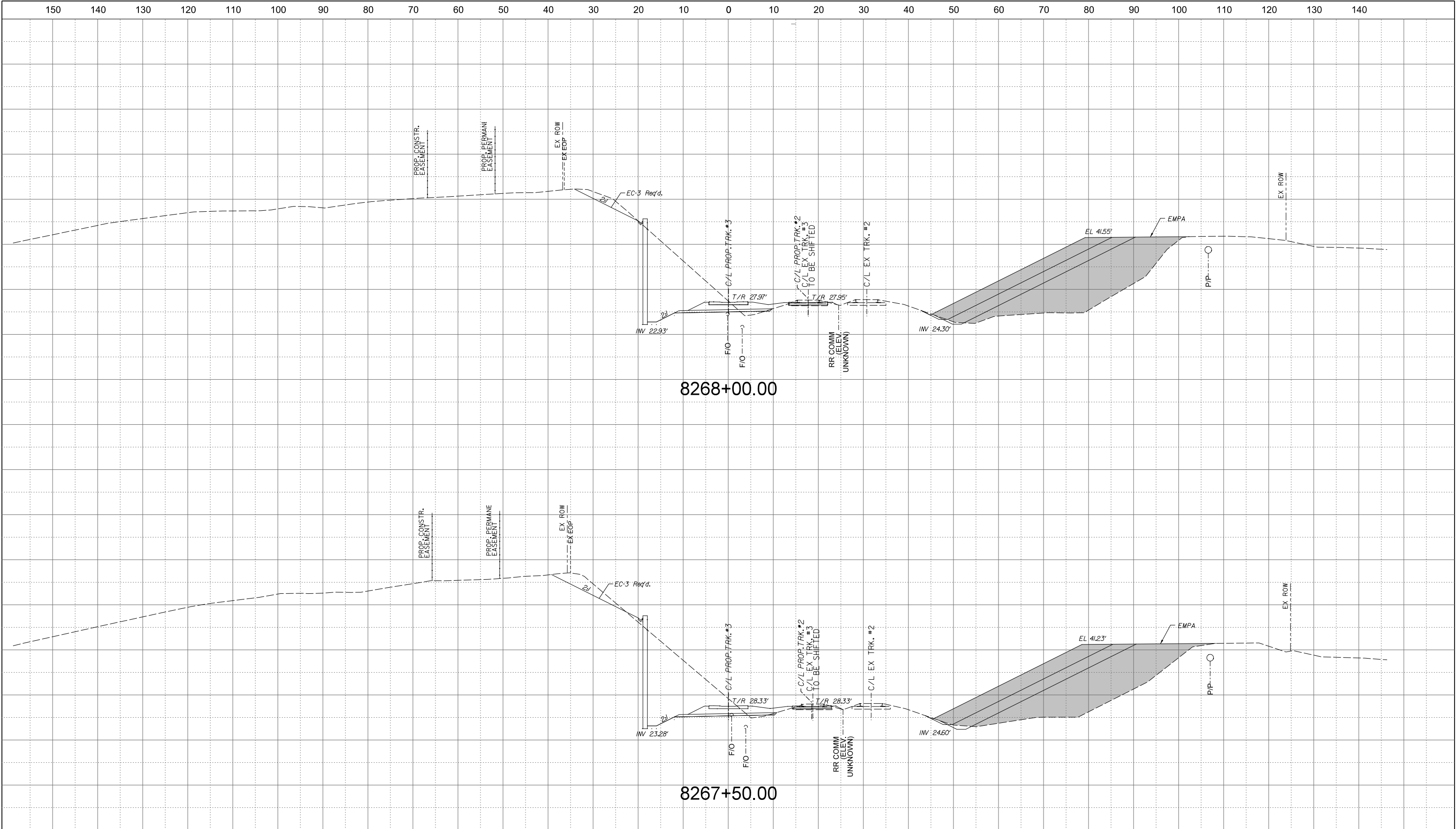
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	0	05/13/20			INVITATION FOR BID	KRJ
						DRAWN BY:
						KRJ
						CHECKED BY:
						RCB
						DATE:
						05/13/2020

STV Incorporated
2701 Prosperity Avenue, Suite 305
Fairfax, Virginia 22031

QUANTICO STATION

STA. 8266+50.00
TO
STA. 8267+00.00

IFB NO:	IFB-020-019
DRAWING NO:	XS-033
SCALE:	1" = 10'
SHEET NO:	OF



INVITATION FOR BID
NOT FOR CONSTRUCTION

NOTE:

1. ALL UTILITY LOCATIONS AND ELEVATIONS SHOWN ARE APPROXIMATE. CONTRACTOR SHALL VERIFY UTILITY BEFORE CONSTRUCTION.

2. PROPOSED RELOCATED PLANTATION PIPELINE IS 30FT BELOW GRADE.

APPROVED BY VRE	REV.NO.	DATE	BY	APP BY	DESCRIPTION
	0	05/13/20			INVITATION FOR BID
APPROVED BY COUNTY					

DESIGNED BY:
KRJ

DRAWN BY:
KRJ

CHECKED BY:
RCB

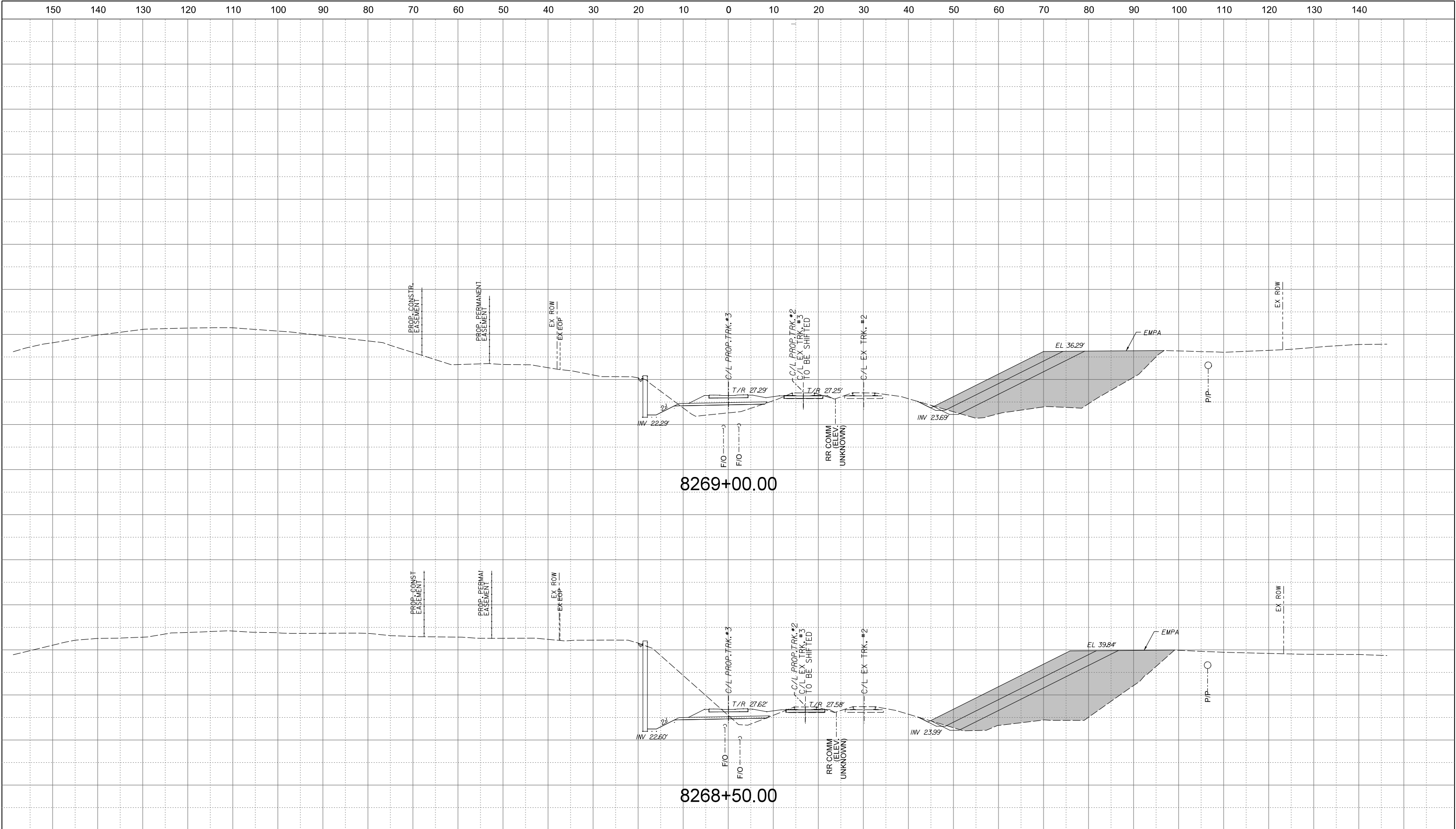
DATE:
05/13/2020

STV Incorporated
2701 Prosperity Avenue, Suite 305
Fairfax, Virginia 22031

QUANTICO STATION

STA. 8267+50.00
TO
STA. 8268+00.00

IFB NO: IFB-020-019
DRAWING NO: XS-034
SCALE: 1" = 10'
SHEET NO: OF



INVITATION FOR BID
NOT FOR CONSTRUCTION

NOTE:

1. ALL UTILITY LOCATIONS AND ELEVATIONS SHOWN ARE APPROXIMATE. CONTRACTOR SHALL VERIFY UTILITY BEFORE CONSTRUCTION.

2. PROPOSED RELOCATED PLANTATION PIPELINE IS 30FT BELOW GRADE.

APPROVED BY VRE	REV.NO.	DATE	BY	APP BY	DESCRIPTION
	0	05/13/20			INVITATION FOR BID
APPROVED BY COUNTY					

DESIGNED BY:
KRJ

DRAWN BY:
KRJ

CHECKED BY:
RCB

DATE:
05/13/2020

STV Incorporated
2701 Prosperity Avenue, Suite 305
Fairfax, Virginia 22031

QUANTICO STATION

STA. 8268+50.00
TO
STA. 8269+00.00

IFB NO: IFB-020-019
DRAWING NO: XS-035
SCALE: 1" = 10'
SHEET NO: OF