



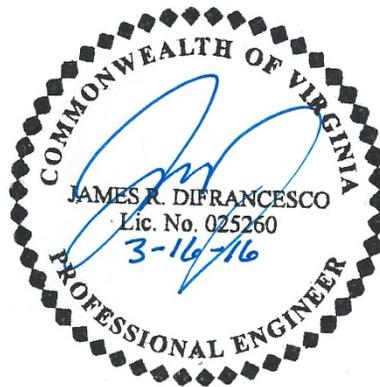
TECHNICAL SPECIFICATIONS

Bremo Power Station – SW Permit #618



Submitted To: Dominion Power
Bremo Power Station
1038 Bremo Bluff Road
Bremo, VA 23022

Submitted By: Golder Associates Inc.
2108 W. Laburnum Avenue, Suite 200
Richmond, VA 23227



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SECTION 000110

TABLE OF CONTENTS

DIVISION 01 – General Requirements

011100	Summary of Work
013300	Submittals
014516	HDPE Pipe and Manhole Leak Testing
015200	Construction Facilities and Temporary Controls
015713	Temporary Erosion and Sediment Controls
015726	Dust Control
017123	Field Engineering and Surveying
017400	Cleaning
017836	Warranties
017839	Project Record Documents

DIVISION 02 – Existing Conditions

022100	Lines and Grades
--------	------------------

DIVISION 03 – Concrete

031000	Concrete Formwork
032000	Concrete Reinforcement
033000	Cast-in-place Concrete
034000	Pre-cast Concrete Structures
036100	Cementitious Grout

DIVISION 31 – Earthwork

310000	Earthwork
310516	Coarse Aggregate
310519.13	Geotextile
310519.16a	HDPE Geomembrane
310519.16b	XR-5 Geomembrane
310519.26	Geonet Composite
311100	Site Clearing and Grubbing
312319	Construction Dewatering
313700	Stone Riprap
314100	Shoring and Bracing

DIVISION 32 – Exterior Improvements

329119	Vegetative Support Layer
329219	Seeding

DIVISION 33 – Utilities

330505	Underground Pipe Abandonment
330513	Manholes/Drop Boxes/Vaults

DIVISION 40 – Process Interconnections

400509 Geomembrane Pipe Boots and Pipe Sleeves

SECTION 011100

SUMMARY OF WORK

PART 1 - GENERAL

1.01 Description

- A. Provide all labor, materials, and equipment to complete improvements as depicted on the construction drawings entitled "Bremono Ash Pond Closure Drawings", dated April 2015, and as described in the Project Procedures Manual containing, but not limited to, the Technical Specifications, Construction Quality Assurance Manual, and the Terms and Conditions for Construction and Maintenance Services.

1.02 Work Covered By Contract Documents

- A. Project Identification: The Project consists of the closure and capping of the North Ash Pond and East Ash Pond, and the closure and repurposing of the West Ash Pond.
- B. Project Location: Bremono Bluff, Virginia
- C. OWNER'S ENGINEER Identification: Golder Associates, Inc., 2108 W. Laburnum Avenue, Suite 200, Richmond, Virginia 23227.
- D. The Work includes but is not limited to:
 - 1. CCR handling and grading in accordance with the design drawings.
 - 2. Dewatering for construction and treatment of effluent water.
 - 3. Installation of geosynthetic caps on the North and East Ash Ponds.
 - 3. Removal of all CCR material from the West Ash Pond
 - 4. Installation of a new bottom liner in the West Ash Pond.
 - 5. Installation of stormwater conveyance systems.

1.03 Use Of Premises

- A. Consistent with the requirements of the Contract, CONTRACTOR shall have full use of premises for construction operations, including use of the Project Site, during the construction period. CONTRACTOR's use of premises is limited only by OWNER's right to perform work or to retain other contractors on portions of other work related to this Project.

1.04 Specification Formats And Conventions

- A. Specification Format: The Specifications are organized into divisions and sections using the 16-division format and CSI/CSC's "MasterFormat" numbering system.

- B. Section Identification: The Specifications use section numbers and titles to help cross-referencing in the Contract. Sections in the Project Procedures Manual are in numeric sequence; however, the sequence is incomplete. Consult the table of contents at the beginning of the Project Procedures Manual to determine numbers and names of sections in the Contract.
- C. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:
1. Abbreviated Language: Language used in the Specifications and elsewhere in the Contract may be abbreviated. Words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be inferred as sense requires. Singular words shall be interpreted as plural and plural words shall be interpreted as singular where applicable as the context of the Contract indicates.
 2. Imperative mood and streamlined language are generally used in the Specifications. Requirements expressed in the imperative mood are to be performed by CONTRACTOR. Occasionally, the indicative or subjunctive mood may be used in the section text for clarity to describe responsibilities that must be fulfilled indirectly by CONTRACTOR or by others when so noted.
 3. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.
- D. Reference to Standard Specifications: Reference to standard specifications such as ASTM, ANSI, AWWA, etc. shall be the specification in effect on the Effective Date (or such future effective date if such date is known on the Effective Date) unless otherwise stated.
- E. Intent of Drawings:
1. The drawings are diagrammatic only, intending to show general features and locations of piping, equipment, fixtures and specialties, and do not necessarily show all required offsets and details. All Work shall be accurately laid out with reference to the drawings and in cooperation with other trades to avoid conflicts and to obtain a neat and workmanlike installation.
 2. The drawings are not intended to be rigid in specific details and where they may be in conflict with requirements of the other drawings, or of any applicable Laws and Codes, or with recommendations of the manufacturers of any equipment actually furnished, installed or connected, the Work hereunder includes the making of such adjustments as may be required to cause all such equipment to be installed and connected in conformance with such codes, ordinances or recommendations for the safe, proper and efficient operation of the equipment.

- F. Discrepancies on Plans and Specifications: If the CONTRACTOR observes that the drawings and specifications are at difference therewith, he shall promptly notify the OWNER'S ENGINEER and OWNER in writing, and any necessary changes shall be adjusted as provided in the contract for changes in the Work. If the CONTRACTOR performs any Work knowing such differences occur, or that the Work is contrary to any Laws and Codes, the CONTRACTOR shall bear all cost arising there from.
- G. Tools, Plant and Equipment: In addition to any other rights or remedies set forth elsewhere, if at any time before the commencement or during the progress of the Work, tools, plant or equipment appear to the OWNER to be insufficient, inefficient, or inappropriate to secure the quality of the Work required or the proper rate of progress, the OWNER may order the CONTRACTOR to increase their efficiency, to improve their character, to augment their number or to substitute new tools, plant, or equipment as the case may be, and the CONTRACTOR must conform to such order, but the failure of the OWNER to demand such an increase of efficiency, number or improvement shall not relieve the CONTRACTOR of his obligation to secure the quality of work and the rate of progress necessary to complete the Work within the time allowed and to the satisfaction of the OWNER.
- H. Not Used.
- I. Codes, Laws, and Regulations:
1. All Work to be performed under this section be in compliance with all Laws and Codes, including those governing standards of design, construction workmanship, materials, types of equipment, and methods of installation in Fluvanna County, Virginia. If the CONTRACTOR performs any Work knowing it to be contrary to Laws and Codes, and without such notice to the OWNER'S ENGINEER and OWNER, it shall bear all cost arising therefrom.
 2. It shall be the CONTRACTOR's responsibility to prepare, have approved, and comply with an 'Erosion and Sediment Control Plan' as approved by Owner per Section 015713 – Temporary Erosion and Sediment Control, and to otherwise comply with the erosion and sediment control Laws and Codes.
- J. Safety and Health Requirements: The CONTRACTOR shall comply with the Department of Labor's Safety and Health Requirements for construction promulgated under the Occupational Safety and Health Act of 1970 (PL 91-596) and under Section 107 of the Contract Work Hours and Safety Standards Act (PL 91-54) and all amendatory requirements thereof.
- K. Accidents: The CONTRACTOR shall provide, at the Project Site, such equipment and medical facilities as necessary to supply first-aid service to anyone who may be injured. The CONTRACTOR must promptly report in writing to the OWNER all accidents whatsoever arising out of, or in connection with the performance of the work whether on, or adjacent to, the Project Site and which caused death, personal injury, or property damages, giving full details and statements of witnesses. In addition, if death or serious injuries or serious damages are caused, the accident shall be reported immediately by telephone or messenger to OWNER. If any claim is made by anyone against the CONTRACTOR or any Subcontractor on account of any accident, the CONTRACTOR shall promptly report the facts in writing to the OWNER, giving full details of the claim.

PART 2 - PRODUCTS

2.01 Submittals

- A. Submittals for all products/materials used on the Project shall be provided by the CONTRACTOR for the OWNER's and OWNER'S ENGINEER's review. The submittals shall include, but not be limited to geosynthetics, soils, soil stabilization blankets, precast concrete structures, HDPE pipe, HDPE manholes, seed mixes, culvert pipes, drainage stone, riprap, aggregate, etc.

PART 3 - EXECUTION

3.01 General Responsibilities of the CONTRACTOR

- A. CONTRACTOR shall execute all construction Work stated in this Section and in the manner specified or illustrated in the Contract and drawings. Any omission in these Specifications does not release the CONTRACTOR from the responsibility to complete the Work or any part of the Work to the satisfaction of the OWNER.
- B. The CONTRACTOR shall provide construction support facilities including, but not limited to, an office trailer, waste dumpsters, temporary utilities, etc., as necessary to support all construction activities throughout the duration of the Project.
 1. CONTRACTOR shall provide telephone and sanitary systems for these structures as required.
 2. CONTRACTOR shall provide and maintain Support Facilities for the Work, which shall include a furnished office trailer with electricity and (2) telephones-land lines and (2) sanitary facilities (men and women) for use by the OWNER and OWNER'S ENGINEER during the Project.
 - a. Offices and sanitary facilities shall be cleaned regularly.
 - b. Offices and trailers shall meet all Laws and Codes, including federal, state, and local requirements.
 - c. Supplier shall obtain all necessary permits for these facilities. OWNER shall have right of access to these facilities.
 3. The size, quantity, appearance, and location of Support Facilities shall be approved by the OWNER before such facilities may be brought on the Project Site or erected.
 4. Upon completion of the Work, Supplier shall promptly remove all Support Facilities from OWNER property and/or the Project Site.
 5. CONTRACTOR shall be responsible for distribution, operation, and maintenance of telephones and temporary power from utility supplied points.

- C. CONTRACTOR shall develop, and submit to the OWNER, a Spill Prevention Control and Countermeasure (SPCC) Plan for the fuels and oils stored and used on the Project Site during the Project. The SPCC plan must cover storage tanks, tank trucks, and equipment used on the Project Site during the Project. The SPCC plan shall be certified by a professional engineer licensed in the Commonwealth of Virginia.
- D. CONTRACTOR shall be responsible for the implementation, maintenance, and inspection of all Project-specific Permits obtained by the OWNER, including but not limited to, Erosion and Sediment (E&S) control, Virginia Stormwater Management Program (VSMP), and other land disturbance Permits issued for the Project. The OWNER has obtained both the necessary E&S and VSMP permits for the Project from Fluvanna County and the Virginia Department of Environmental Quality (DEQ). The CONTRACTOR shall ensure that all special and general permit conditions are complied with during all phases of construction and be responsible for any repairs, corrective actions, or additional work necessary to fulfill the Permit requirements at CONTRACTOR's sole expense.
- E. CONTRACTOR shall provide field surveying and Construction Quality Control (CQC) testing as necessary to comply with the construction drawings and technical Specifications.
- F. [Reserved]
- G. The CONTRACTOR shall provide all measures to maintain, control, and protect traffic at the intersections of any public or private roads and access roads to and on the Project Site.

3.02 General Responsibilities of the OWNER

- A. The OWNER will supply available water for dust control and soil compaction, which can be drawn from on-site ponds. No other water source is available on the Project Site.
- B. The OWNER will supply third-party construction quality assurance consultant (the "CQA Consultant") to confirm that the Work performed by the CONTRACTOR(s) is in compliance with the approved construction drawings and technical Specifications.
- C. The OWNER will supply surveying for construction certification only.

3.04 General Work Tasks

- B. Remove trees and vegetation from each unit per the technical Specifications.
 - 1. Root balls shall be removed under the observation of the CQA Consultant to observe for ash mixed with the root ball soils. Root balls mixed with ash shall be stockpiled on the ash unit in accordance with the technical Specifications until removed for disposal.
 - 2. Grub soil to remove all roots and woody vegetation and stockpile until removed for disposal.
- C. Soil Stripping and Stockpiling

1. The CONTRACTOR will be responsible for the necessary equipment and labor to prepare and maintain the stockpile areas, including E&S measures, stockpiling the material, hauling to and placing the material in the work area.
2. Existing cover soils shall be stripped and stockpiled for reuse to the maximum extent practicable. The CONTRACTOR will be responsible for the necessary equipment and labor to prepare and maintain the stockpile areas, including E&S measures, stockpiling the material, hauling to and placing the material in the work area.
3. Representative samples of off-site soil shall be submitted for conformance testing and approval prior to bringing the material on-site.

D. Dewatering

1. The CONTRACTOR shall be responsible for designing, implementing, and decommissioning appropriate dewatering techniques that conform to applicable effluent regulations. Most dewatering on the Project Site will involve the treatment of CCR-contaminated leachate. The expected pollutants and levels are included in Section 009300 – Clarifications.

E. CCR Grading

1. The CONTRACTOR shall grade the CCR storage unit's surface to meet the final grades, minus two (2) feet, as shown on the Contract drawings.
2. The CONTRACTOR shall be responsible for control and/or diversion of stormwater to prevent erosion of the CCR surface.
3. The CONTRACTOR shall maintain the exposed CCR surface to prevent dusting prior to placement of the geomembrane liner.

F. Material Storage

1. The CONTRACTOR shall make arrangements for the storage and protection of materials, equipment, and debris. Locations and configurations of such facilities shall be as shown on the Contract drawings, in accordance with the technical Specifications, and subject to the approval of the OWNER.

G. Geosynthetics

1. The CONTRACTOR shall be responsible for supplying, unloading, storing, and installing all geosynthetic materials at the site, to include HDPE geomembrane, geocomposite, CHDPE and HDPE pipe, HDPE manholes, and concrete products.
2. The OWNER will arrange for geosynthetic conformance testing by an independent laboratory.
3. The CONTRACTOR shall supply and install all other required geosynthetics associated with erosion and sediment control, roads, etc.

H. Cover Soil

1. Following placement and approval of geosynthetic materials, the CONTRACTOR shall install the final cover soil to the lines and grades shown on the Contract drawings, in compliance with the technical Specifications. Off-site soil shall be supplied and installed by the CONTRACTOR, as needed, to meet the required grades and construct stormwater control features.

I. Seeding and Stabilization

1. CONTRACTOR will supply and install soil stabilization matting, seeding, fertilizer, lime, and mulch on the final cover soil in areas designated on the Contract drawings.
2. CONTRACTOR will supply and install seeding on remaining soil stockpile areas once stockpile activities are complete, as well as on any other areas disturbed during construction.

J. Stormwater Controls

1. CONTRACTOR will supply and install concrete pipes, HDPE pipes, headwalls, endwalls, riprap, channels, lined channels, and other stormwater control features as shown on the Contract drawings.

3.04 Inspections And Tests

- A. Inspections and Tests at Mills and Site Installations: Where deemed necessary, inspections and tests of material and equipment may be made at the place of manufacture prior to shipment. In order to facilitate such shop or mill inspection, the CONTRACTOR shall immediately, upon placing orders for materials and equipment, mail copies of such orders to the OWNER, and shall afford ample time to permit the OWNER to have proper and necessary tests made prior to any shipment.
- B. Tests of Work in place: The following tests are specified for work under this Section and shall be successfully completed prior to Project Completion.
1. Geomembrane conformance and installation testing.
 2. Leakage test for pressure pipe, gravity pipes, and stormwater structures.
 3. Performance test for water treatment system.

* * * * * END OF SECTION * * * * *

SECTION 013300

SUBMITTALS

PART 1 - GENERAL

1.01 Description Of Work

- A. Wherever submittals are required hereunder, all such submittals by the CONTRACTOR shall be submitted to OWNER and to the OWNER'S ENGINEER.
- B. Within ten (10) Days after the Effective Date:
 - 1. A preliminary schedule of "Shop Drawing" (as defined below), sample, and proposed substitutes or "or equal" submittals.
- C. Any details deemed by the CONTRACTOR as required for performance of the Work but not indicated on any plans or drawings shall be submitted to OWNER and the OWNER'S ENGINEER for review and approval at least ten (10) Days prior to mobilization to the Project Site. Responsibility for identifying such details is the responsibility of the CONTRACTOR.

1.02 Shop Drawing Submittal

- A. Whenever called for in the Contract or this Exhibit A, or where required by the OWNER, CONTRACTOR shall furnish to the OWNER and OWNER'S ENGINEER for review, 5 copies of each shop drawing submittal. The term "Shop Drawings" as used herein shall be understood to include detailed design calculations, shop drawings, fabrication and installation drawings, erection drawings, lists, graphs, operating instructions, catalog sheets, data sheets, and similar items.
- B. All Shop Drawing submittals shall be accompanied by a submittal transmittal form.
- C. Except as may otherwise be provided herein, OWNER shall attempt to, or shall attempt to cause OWNER'S ENGINEER to, return 2 prints of each submittal to the CONTRACTOR with its comments noted thereon, within ten (10) Business Days following their receipt by OWNER or, if applicable, OWNER'S ENGINEER.
- D. All CONTRACTOR Shop Drawing submittals shall be carefully reviewed by an authorized representative of the CONTRACTOR, prior to submission to OWNER and to OWNER'S ENGINEER. Each submittal shall be dated and signed by the CONTRACTOR, as being correct and in strict conformance with the Contract. In the case of Shop Drawings, each sheet shall be so dated and signed. All noncertified submittals will be returned to the CONTRACTOR and any delays caused thereby shall be the total responsibility of the CONTRACTOR.
- E. The CONTRACTOR shall present Shop Drawings at least one (1) Month before Work is due to start on that item.

- F. CONTRACTOR shall provide to the OWNER a binder of the approved Shop Drawings, including intermediate reviews, prior to Project Completion.

1.03 Proposed Substitutes Of "Or Equal" Items:

- A. Whenever Materials and Equipment are specified or described in the Contract Implementation Documents by using the name of a proprietary item or the name of a particular supplier, the naming of the item is intended to establish the type, function, and quality required. If the name is followed by the words "or equal" indicating that a substitution is permitted, Materials and Equipment may be accepted by OWNER if sufficient information is submitted by the CONTRACTOR to allow OWNER to determine if the substitution is acceptable.
1. The burden of proof as to the type, function, and quality of any such substitute material or equipment shall be upon the CONTRACTOR.
 2. The OWNER will determine as to the type, function, and quality of any such substitute item.
 3. The OWNER may require the CONTRACTOR to furnish at the CONTRACTOR's expense additional data about the proposed substitute.
 4. The OWNER may require the CONTRACTOR to furnish at the CONTRACTOR's expense a special performance guarantee or other surety with respect to any substitution.
 5. Acceptance by the OWNER of a substitute item proposed by the CONTRACTOR shall not relieve the CONTRACTOR of the responsibility for full compliance with the Contract and for adequacy of the substitute item.
 6. The CONTRACTOR shall be responsible for resultant changes and all additional costs which the accepted substitution requires.
- B. The procedure for review by the OWNER and OWNER'S ENGINEER will include the following:
1. If the CONTRACTOR wishes to furnish or use a substitute item of material or equipment, the CONTRACTOR shall make written application to OWNER and the OWNER'S ENGINEER.
 2. The CONTRACTOR shall certify that the proposed substitute will perform adequately the functions and achieve the results called for by the general design, be similar and of equal substance to that specified, and be suited to the same use as that specified.
 3. The OWNER and OWNER'S ENGINEER will be allowed a reasonable time within which to evaluate each proposed substitute.

4. As applicable, no Shop Drawing submittals will be made for a substitute item nor will any substitute item be ordered, installed, or utilized without the OWNER and OWNER'S ENGINEER'S prior written acceptance of the CONTRACTOR's substitution request.
- C. The CONTRACTOR's application shall contain the following statements and/or information which shall be considered by the OWNER and the OWNER'S ENGINEER in evaluating the proposed substitution:
1. The evaluation and acceptance of the proposed substitute will not entitle CONTRACTOR to any extension to the Project Schedule.
 2. Whether or not acceptance of the substitution for use in the Work will require a change in any of the Contract Implementation Documents to adapt the design to the proposed substitute.
 3. Whether or not incorporation or use of the substitute in connection with the Work is subject to payment of any license fee or royalty.
 4. All variations of the proposed substitute for that specified shall be identified.
 5. Available maintenance, repair, and replacement service shall be indicated.
 6. Itemized estimate of all costs that will result directly or indirectly from acceptance of such substitute, including cost of redesign and claims of other contractors affected by the resulting change.

1.05 Manufacturer's Instructions

- A. When specified in individual specification sections, submit manufacturer's printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, in quantities specified for the Work.
- B. Identify conflicts between manufacturer's instructions and Contract Implementation Documents.

1.06 Manufacturer's Certificates

- A. When specified in individual specification sections, submit manufacturer's certificate to OWNER for review as required by this Exhibit A.
- B. Indicate if the material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
- C. Certificates may be recent or previous test results on material or product, but must be acceptable to the OWNER.

1.07 Layout Data

- A. General - The CONTRACTOR is responsible for coordinating work of all trades on the Work. CONTRACTOR shall confer with OWNER and provide guidance and information to all trades as necessary.
- B. Procedures - If requested, by OWNER, CONTRACTOR shall provide detailed drawings as required to indicate construction procedures.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

- A. Repeated failure to present acceptable submittals or excessive services required of OWNER due to repeated presentation of unacceptable submittals results in additional engineering expenses. It will be considered excessive if more than one correction of any submittal is required and will result in a charge against the CONTRACTOR for recovery of additional expenses.

* * * * * END OF SECTION * * * * *

SECTION 014516

HDPE PIPE & MANHOLE LEAK TESTING

PART 1 - GENERAL

1.01 Scope Of Work

- A. CONTRACTOR shall furnish all labor, material, equipment, tools, and appurtenances required to setup and pressure test non-perforated HDPE pipe.
- B. CONTRACTOR shall conduct all pressure testing using water as the testing method. The piping manufacturer and the OWNER shall be consulted before using pressure testing methods other than those presented here. Other pressure testing procedures may or may not be applicable, depending upon piping products and/or piping applications.
- C. CONTRACTOR shall comply with all applicable Laws and Codes. CONTRACTOR shall also comply with all applicable health and safety regulations as required by OSHA and in accordance with the CONTRACTOR's health and safety program as required by the Contract.
- D. CONTRACTOR shall conduct all tests in a manner to minimize as much as possible any interference with the day-to-day operations of existing facilities or other contractors working on the Project Site.

1.02 Related Sections

- A. Manholes/Drop Boxes/Vaults – Section 330513
- B. HDPE Pipe and Appurtenances – Section 400533

1.03 Submittals

- A. Testing Report: Prior to placing the toe drain forcemain system into service, submit for review and approval a detailed report summarizing the leakage test data, describing the test procedure and showing the calculations on which the leakage test data is based. The report shall include, at a minimum, the following information:
 - 1. The length and diameter of the section of line tested.
 - 2. A complete description of test procedures and methods, including:
 - a. Trench backfilling and pipe cleaning status
 - b. Types of plugs used and where
 - c. Stabilization time period and water pressure
 - d. The allowed time by specifications

- e. The actual test time
 - f. The water pressure at the beginning and end of the test.
- 3. The name of the inspector / tester and the date and time of all testing, including any retesting
 - 4. A description of any repairs made.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 Leakage Testing For Pipes

- A. All new non-perforated toe drain forcemain conveyance pipe installed shall be tested for leakage. The test used will be hydrostatic testing. Testing to be performed will be indicated by the OWNER and OWNER'S ENGINEER and witnessed by the CQA Consultant and the OWNER's Representative and OWNER'S ENGINEER.
- B. All pipes shall be flushed to remove all sand and other foreign matter. The velocity of the flushing water shall be at least 4 fps. Dispose of the flushing water without causing a nuisance or property damage.
- C. Test Preparation and Inspection
 - 1. Perform hydrostatic testing of the system as set forth in the following, and perform such testing in the presence of the CQA Consultant and the OWNER's Representative. CONTRACTOR shall give Owner at least 48 hours' Notice of planned testing.
 - 2. Piping and appurtenances to be tested shall be sections of at least 250 feet in length, unless unavoidable. All piping shall be thoroughly cleaned and flushed prior to testing to clear the lines of foreign matter. While the piping is being filled with water, care shall be exercised to permit the escape of air from the extremities of the test section, with additional release cocks (provided by the CONTRACTOR) if required. Venting may be provided by loosening flanges. Retighten any loosened flanges before applying test pressure.
 - 3. Test equipment and the pipeline should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in place and secure, and components that should be isolated or disconnected are isolated or disconnected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.
 - 4. If a lower pressure rated component the system cannot be removed or isolated, then the maximum allowable test pressure is the allowable pressure of the component.

D. Monitored Make-Up Water Test

1. The test procedure consists of initial expansion and test phases. During the initial expansion phase, the test section is pressurized to the test pressure, and sufficient make-up water is added each hour for three (3) hours to return to test pressure.
2. After the initial expansion phase, the test phase begins. The test phase may be one (1), two (2), or three (3) hours, after which a measured amount of water is added to return to test pressure. If the amount of water does not exceed the amount shown in Table 02560-1, leakage is not indicated.
3. The testing procedure shall consist of the continued application of the specified pressure to the test system for the duration of the test period, by way of a pump taking supply from a container suitable for measuring water loss. The amount of loss shall be determined by measuring the volume of water taken from said container.
4. Hydrostatic testing shall be performed with a sustained pressure after the expansion phase for a minimum of one (1) hour at 1-1/2 times the working pressure of the pipe, unless otherwise approved by the OWNER. The allowable leakage shall be less than the number of gallons per hour determined from the following table:

Table 02560-1 - Test Phase Make-Up Amount

Nominal Pipe Size, in.	Make-Up Water Allowance (U.S. Gallons per 100 ft of Pipe)		
	1 Hour Test	2 Hour Test	3 Hour Test
2	0.07	0.11	0.2
3	0.10	0.18	0.3
4	0.13	0.25	0.4
6	0.3	0.6	0.9
8	0.5	1.0	1.5
10	0.8	1.3	2.1
12	1.1	2.3	3.4
14	1.4	2.8	4.2
16	1.7	3.3	5.0
18	2.0	4.3	6.5

5. The testing duration, including initial pressurization, initial expansion, and time at test pressure must not exceed eight (8) hours. If the pressure test is not completed due to leakage, equipment failure, etc. the test section shall be depressurized and allowed to “relax” for eight (8) hours before bringing the test section up to test pressure again.

3.02 Leakage Testing For Hdpe Structures

- A. Perform leakage testing for vaults, wet wells, and manholes prior to backfilling by filling the structure with water to the overflow level and observing the water level for the following 24 hours.
- B. Make an inspection for leakage of the exterior surface of the structure, especially in areas around construction joints.
- C. Leakage will be accepted as within allowable limits for structures from which there are no visible leaks and the leakage rate does not exceed 0.002 gallon per 100 gallons of computed capacity per hour. Method for testing leakage shall be submitted to the OWNER and OWNER'S ENGINEER prior to testing.
- D. If visible leaks appear, repair the structure by removing and replacing the leaking portions of the structure, waterproofing the inside, or by other methods approved.
- E. Water for testing will be provided by the OWNER.
- F. Submit a report describing the manhole description, duration of test, results of testing, and any repairs made.

* * * * * END OF SECTION * * * * *

SECTION 015200

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 – GENERAL

1.01 Protection And Safety

- A. The CONTRACTOR shall not interfere with any landfill operations. All monitoring wells, gas probes, liner systems, existing leachate and stormwater piping and appurtenances, and utilities shall be protected.
- B. Do not interfere with use of, or access to, adjacent buildings. Maintain free and safe passage to and from all facilities.
- C. Protect trees, shrubs, lawns, areas to receive planting, rock outcropping, and other features remaining as part of final landscaping.
- D. Protect bench marks and existing structures, property corners, roads, sidewalks, paving, and curbs against damage from equipment and vehicular or foot traffic.
- E. Cease operations and notify the OWNER and OWNER'S ENGINEER immediately if safety of adjacent structure(s) appears to be endangered. Do not resume operations until safety is restored and OWNER and OWNER'S ENGINEER provides notifications to resume the Work.
- F. Prevent movement, settlement, or collapse of adjacent services, utilities, structures, trees, and etc. Assume liability for such movement, settlement, or collapse. Promptly repair damage at no cost to the OWNER.
- G. Provide, erect, and maintain street boardings, sidewalk sheds, barricades, lighting, and/or guard rails as required to protect general public, workers, and adjoining property.
- H. Protect excavations by shoring, bracing, sheet piling, underpinning, or other methods, as required to prevent cave-ins or loose dirt from falling into excavations.
- I. Notify OWNER and OWNER'S ENGINEER of unexpected sub-surface conditions and discontinue work in area until OWNER and OWNER'S ENGINEER provides notification to resume the Work.
- J. Protect bottom of excavations and soil around and beneath foundations from frost.
- K. Ensure all required environmental protection devices and procedures are in place, properly maintained, and operational.

1.02 Temporary Field Office

- A. Provide and maintain a suitable temporary field office at the Project Site for Contractor's own use and the use of OWNER and the OWNER'S ENGINEER. Provide inside toilets and lavatory (or adjacent portable unit), drinking and wash water, electric power, lights,

heating and cooling. Provide equipment as follows: copy machine, desk, desk chair, side chair, plan review table.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

NOT USED

***** END OF SECTION *****

SECTION 015713

TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.01 Description Of Work

- A. The CONTRACTOR shall provide all materials and promptly take all actions necessary to achieve effective erosion and sedimentation control in accordance with all Laws and Codes, the Contract, and these Specifications. CONTRACTOR shall provide a "Competent Person" to implement and supervise all work.
- B. The measures and requirements shown on the Contract Drawings and working drawings shall be considered a minimum requirement and shall not relieve the CONTRACTOR of the responsibility to actively take all steps necessary to control soil erosion and sedimentation.
- C. Comply with all Laws and Codes.
- D. CONTRACTOR shall repair any material or existing surface conditions damaged by erosion or covered with sedimentation at the CONTRACTOR's expense.
- E. Erosion Control Measures shall be provided for all Work activities in the closure cap construction area as well as other related work throughout the Project Site. CONTRACTOR shall maintain at least 20% overstock of erosion control items stockpiled on-site or have ready access to needed items via a supplier for ease of use to replace installed items as deemed necessary.
- F. The temporary erosion control features installed by the CONTRACTOR shall be maintained by the CONTRACTOR until no longer needed as determined by the OWNER, or permanent erosion control methods are installed.
- G. It shall be the sole responsibility of the CONTRACTOR to properly schedule and coordinate all necessary labor, equipment, and materials such that the specified Work is performed in accordance with the Project Schedule and the Contract requirements. At the discretion of the OWNER, the OWNER may reject or direct the CONTRACTOR to repair (at the CONTRACTOR's sole expense) those items which are detrimental to the Project or not in compliance with the Contract Documents. Such direction or rejection by the OWNER shall not relieve the CONTRACTOR of his obligation to properly schedule and perform other specified Work items in conformance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Earthwork – Section 310000
- B. Coarse Aggregate – Section 310516
- C. Geotextile – Section 310519.13
- D. Seeding – Section 329219

E. Virginia Erosion and Sediment Control Handbook Standards and Specifications.

1.03 Submittals

A. At the preconstruction conference, the CONTRACTOR shall submit for OWNER's approval, a schedule and construction drawing for accomplishment of temporary and permanent erosion control work, as applicable for clearing and grubbing, grading, structures at watercourses, and general construction. No Work shall be started until the erosion control schedules and methods of operations for each phase of the Work have been accepted by the OWNER. This plan will be referred to as the CONTRACTOR's Soil Erosion and Sediment Control Plan.

PART 2 - PRODUCTS

2.01 Silt Fence

A. Silt fence shall be Filter X, Mirafi 100X, Stabilinka T140N, or approved equal.

2.02 Bales

A. Straw bales shall be clean, seedfree oat or wheat type.

2.03 Seed

A. Seed type shall meet the requirements of Section 329219 "Seeding".

2.04 Temporary Erosion Control Mat

A. Temporary Erosion Control Mat shall be either a natural or synthetic material that is photo- and bio-degradable matting suitable for seed establishment and capable of offering erosion protection for at least one growing season. CONTRACTOR shall supply information on proposed material to the OWNER'S ENGINEER for approval.

PART 3 - EXECUTION

3.01 General

A. The Project-Specific erosion and sediment construction sequence outlined on the Project's construction drawings will contain specific items tailored for that construction activity, including required pre-construction meetings and inspections.

B. Conduct earthwork and excavation activities in such a manner to fit the topography, soil type, and condition.

C. Minimize the area being disturbed and the duration of exposure to erosion elements.

D. Stabilize disturbed areas immediately.

- E. Retain on-site, sediment that was generated on-site. Place sediments under cover after dewatering, during construction, and dispose of soil sediments at the landfill if not laden with seeps or perched groundwater. Sediment containing CCR shall be disposed of in the CCR facility.
- F. Prevent silt and sediment from entering any watercourse if soil erosion cannot be prevented.
- G. Prevent silt and sediment from migrating downstream in the event it cannot be prevented from entering the watercourse.
- H. Where provisions of pertinent rules and regulations conflict with these Specifications, the more stringent provisions shall govern.
- I. The OWNER has the authority to limit the surface area of erodible material exposed by clearing and grubbing, and to direct the CONTRACTOR to provide immediate temporary or permanent control measures to prevent sediment impact on adjacent watercourses.
- J. Where erosion is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter if the Project conditions permit; otherwise, erosion control measures may be required between successive construction stages. Under no circumstances shall the total aggregate surface area of erodible material (i.e. exposed soil, ash, or erodible material without vegetation or surface erosion protection) exposed at any given time, exceed 20 acres without approval by the OWNER. The Owner may permit additional areas to be exposed based on the performance of the erosion and sediment control maintenance measures.
- K. The OWNER will limit the area of excavation, and embankment operations in progress commensurate with the CONTRACTOR's capability and progress in keeping the finish grading, mulching, seeding, and other such permanent control measures current in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measure shall be taken immediately to the extent feasible and justified.
- L. In the event that additional temporary erosion and sedimentation control measures are required due to the CONTRACTOR's negligence, carelessness, or failure to install permanent controls as a part of the work schedule, and are ordered by the OWNER, such work shall be performed by the CONTRACTOR at the CONTRACTOR's expense, and no time extension shall be given.

3.02 Temporary Erosion And Sedimentation Control

- A. Temporary erosion control measures shall be used to correct conditions that develop during performance of the Work that lead to soil erosion or deposition of waterborne sediments; that are needed prior to installation of permanent erosion control features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the Project.

- B. Temporary erosion and sedimentation control devices shall be installed and maintained prior to the initial land disturbance activity until the satisfactory completion and establishment of permanent erosion control measures. At that time, temporary devices shall be removed.
- C. The CONTRACTOR shall coordinate the installation of temporary erosion and sedimentation control provisions contained herein with the permanent erosion control features, to ensure economical, effective, and continuous erosion control throughout the construction and post-construction period.
- D. Temporary erosion and sedimentation control procedures should be initially directed toward preventing silt, and sediment from entering the watercourses. The preferred method is to provide an undisturbed natural buffer, extending a minimal 5 feet from the top of the bank, to filter the run-off.
- E. Silt fences, barriers, temporary sedimentation basins and other temporary measures and devices shall be installed, and shall be maintained until no longer needed, as determined by the OWNER. At that time, the items shall be removed by the CONTRACTOR. All temporary items and devices must be removed with the OWNER's approval prior to final demobilization from the Site.
- F. Where permanent vegetation is not appropriate, and where the CONTRACTOR's temporary erosion and sedimentation control practices are inadequate, the CONTRACTOR shall provide temporary vegetative cover. Such temporary vegetative cover shall be provided by the CONTRACTOR in compliance with Section 329219 "Seeding" of these specifications.
- G. All erosion and sedimentation control devices shall be inspected by the CONTRACTOR at least weekly and after each rainfall occurrence, and cleaned out and repaired by the CONTRACTOR as necessary.

3.03 Temporary Erosion And Sediment Control Techniques

A. Temporary Diversion Berms

- 1. A temporary diversion berm is constructed of compacted soil, with or without a shallow ditch, at the top of fill slopes.
- 2. These diversion berms are used temporarily at the top of newly constructed slopes to prevent excessive erosion until permanent controls are installed or slopes stabilized.
- 3. A temporary diversion berm shall be constructed of compacted soil, with a minimum width of 24-inches at the top and a minimum height of 12-inches with or without a shallow ditch. Side slopes shall be three horizontal to one vertical (3H:1V) or flatter.

B. Sediment Control Structures

- 1. Sediment basins, ponds and traps, are prepared storage areas constructed to trap and store sediment from erodible areas in order to protect stream channels below the construction areas from excessive siltation.

2. Sediment structures shall be utilized to control sediment where slope drains outlet. All sediment structures shall be at least twice as long as they are wide.
3. When use of temporary sediment structures is to be discontinued, all sediment accumulation shall be removed and all excavation backfilled and properly compacted. The existing ground shall be restored to its natural or intended condition.

D. Riprap

1. Unless shown otherwise on the Contract Drawings, riprap shall be placed where ordered by the OWNER and at all points where banks of streams or drainage ditches are disturbed by excavation. Fill or backfill shall be carefully compacted and riprap placed to prevent subsequent settlement and erosion. This requirement applies equally to construction alongside a stream or drainage ditch as well as crossing a stream or drainage ditch.

E. Straw Bales

1. Straw bales are temporary measures to control erosion and retain the suspended silt particles in the runoff water leaving disturbed areas. Bales shall contain five cubic feet or more of material.
2. Straw bales shall be embedded in the ground 4 to 6-inches to prevent water flowing under them. The bales shall also be anchored securely to the ground by wooden stakes driven through the bales into the ground. Bales shall be removed after they have served their purpose, as determined by the OWNER.
3. The CONTRACTOR shall keep the bales in good condition by replacing broken or damaged bales immediately after damage occurs. Normal debris clean-out will be considered routine maintenance.
4. Straw bales shall be used at the toe of fill slopes, in ditches, or other areas where siltation, erosion, or water run-off is a problem.

F. Silt Fences

1. Silt fences are temporary measures utilizing woven wire or other approved materials attached to posts with filter cloth attached to the upstream side of the fence to retain the suspended silt particles in the runoff water.
2. Temporary silt fences shall be placed on the natural ground, at the toe of fill slopes, in ditches or other areas where siltation is a problem. Temporary silt fences shall be anchored as indicated on the Contract Drawings.
3. The CONTRACTOR shall be required to maintain the silt fence in a satisfactory condition for the duration of the Work or until its removal is requested by the OWNER. The silt accumulation at the fence must be removed and placed on the Project Site as directed by the OWNER.

G. Temporary Vegetation

1. Temporary vegetation are measures consisting of seeding, mulching, fertilizing and matting utilized to reduce erosion. All cut and fill slopes shall be seeded when and where necessary to eliminate erosion. Disturbed or bare soil areas shall not be left without stabilization for more than 30 days.
2. Seeding, mulching and fertilizing shall be performed in accordance with Section 329219 "Seeding" of these Specifications.
3. If late fall completion prevents germination. Disturbed areas shall be protected by mulching without application of seed as a minimum. Seeding shall then be performed no later than April 15th of the following spring.

3.04 Permanent Erosion And Sediment Control

- A. The CONTRACTOR shall incorporate all permanent erosion control features into the Work at the earliest practicable time as outlined in the CONTRACTOR's Soil Erosion and Sediment Control Plan accepted schedule or as land disturbance for each segment of the Work has been completed.
- B. Restore the work site to its original contours, unless shown otherwise on the Drawings or directed by the OWNER.
- C. All references to permanent vegetation, unless noted otherwise, shall relate to establishing permanent vegetative cover and be in accordance with Section 0329219 "Seeding" of these specifications.
- D. When final grade has been established, all bare soil, unless otherwise required by the Contract Documents, shall be seeded, fertilized, and mulched in an effort to restore to a protected condition. Areas that are not stabilized with seed and mulch shall be sodded as approved or directed by the OWNER.
- E. Specified permanent vegetation shall be established at the first appropriate season following establishment of final grading in each section of the Project Site.
- F. Where sod is removed or damaged, such areas shall be replanted using sod of the same species of grass at the first appropriate season.
- G. Permanent vegetative cover activities shall comply with local soil and water conservation guidelines.
- H. Where permanent vegetative cover cannot be immediately established (due to season or other circumstances), the CONTRACTOR shall provide temporary vegetative cover.

3.05 Permanent Erosion And Sediment Control Techniques

- A. Permanent Vegetation

1. All references to permanent vegetation, unless noted otherwise, shall relate to establishing permanent vegetative cover and be in accordance with Section 0329219 "Seeding" of these specifications.

* * * * * END OF SECTION * * * * *

SECTION 015726

DUST CONTROL

PART 1 - GENERAL

1.01 Description of Work

- A. The CONTRACTOR shall employ construction methods and means that keep airborne particulates to the minimum and shall provide for the application of water or employ other appropriate preventive means or methods to maintain dust control, subject to the approval of the OWNER.
- B. Dust control measures shall be compatible with existing on-site materials and proposed materials.

1.02 Related Sections

- A. Earthwork – Section 310000

PART 2 – PRODUCTS

NOT USED

PART 3 - EXECUTION

- A. During grading activities, soils and coal materials will be treated using wet suppression for dust control. Watering equipment shall be used to minimize airborne concentrations and shall consist of pipelines, tank trucks, or other devices approved by the OWNER, which are capable of applying a uniform spread of water over the ground surface. A suitable device for a positive shut-off and for regulating the flow rate of water shall be located so as to permit positive operator control. Calcium chloride is not allowed for dust control.
- B. Minimize the exposed area of disturbed material.
- C. Depending on the expected weather conditions, exposed disturbed material may only be left exposed over night after wet suppression treatment and sealing with smooth drum roller.
- D. Stabilize exposed subgrade with wet suppression treatment and sealing with smooth drum roller if liner system is not installed in the same day.
- E. Project Site activities may be suspended if sustained wind speeds exceed 25 mph or during adverse weather conditions.

* * * * * END OF SECTION * * * * *

SECTION 017123

FIELD ENGINEERING AND SURVEYING

PART 1 - GENERAL

1.01 Description Of Work

- A. Work under this Section includes all surveying services for accurate location of all components of the Work and establishing proposed grades.

1.02 Related Sections

- A. Project Record Documents – Section 017839

1.03 Quality Control

- A. CONTRACTOR is responsible for all surveying necessary for control of its Work at the Project Site. Contractor's surveyor shall be a qualified and registered land surveyor in the Commonwealth of Virginia (the "Surveyor"). This Surveyor shall also be approved by OWNER and have a minimum of two years of experience in construction surveying layout and maintenance of as-built construction drawings with a record of performing horizontal and vertical control requirements as stated in the contract.

1.04 Submittals

- A. Name, address, and telephone number of Surveyor shall be submitted to OWNER before starting survey work by CONTRACTOR.
- B. On request, documentation verifying accuracy of survey work shall be submitted to OWNER by CONTRACTOR.

1.05 Survey Requirements

- A. CONTRACTOR shall utilize existing control points and establish new control points as needed to complete work under this section.
- B. CONTRACTOR shall provide field engineering services and use recognized engineering survey practices.
- C. Establish elevations, lines, and levels. Locate and layout by instrumentation and similar appropriate means site improvements including roadways, stakes for grading and fill placement, utility locations, slopes, and invert elevations.
- D. Periodically verify layouts by same means.

1.06 Survey Tolerances

- A. Grading Tolerances shall be as defined in the individual specifications of Division 2, if applicable.

1.07 Record Survey For Certification

- A. Record survey for the purpose of certification of the project shall be provided by the OWNER.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 Inspection

- A. CONTRACTOR shall verify locations of site reference and survey control points prior to starting work. OWNER must be promptly notified of any discrepancies discovered.

3.02 Survey Reference Points

- A. CONTRACTOR shall take measures to protect site reference and survey control points prior to starting Project Site Work, and must preserve permanent reference points during construction. Site reference points may not be relocated without prior written Notice to OWNER.
- B. The OWNER shall be immediately notified of loss, damage, or destruction of any reference point, or relocation required because of changes in grades or other reasons. CONTRACTOR shall replace disturbed survey control points based on original survey control at no extra cost.
- C. X, Y, and Z coordinates of benchmarks and survey control points shall be determined (and recorded) with a maximum permissible error of 0.10 feet (\pm) in any coordinate direction.
- D. All X and Y coordinates are to be referred to the Plant Grid and Plant Datum coordinate system with an accuracy of 0.10 feet (\pm).
- E. All Z coordinates are to be referred to nearest NGVD benchmark with an accuracy of 0.10 feet (\pm).

3.03 Survey Requirements

- A. CONTRACTOR shall reference survey and data reference points to permanent benchmarks and record locations of survey control points, with horizontal and vertical data.
- B. CONTRACTOR shall reverify layouts periodically during construction by same means.

***** END OF SECTION *****

SECTION 017400

CLEANING

PART 1 – GENERAL

1.01 Description

- A. Execute cleaning, during progress of the Work, and at completion of the Work, as required by this Scope of Work and the Contract.

1.02 Disposal Requirements

- A. Conduct cleaning and disposal operations to comply with all Laws and Codes, including all anti-pollution laws, codes, ordinances, and regulations.

PART 2 – PRODUCTS

2.01 Materials

- A. Use only those cleaning materials which will not create hazards to health or property and which will not damage surfaces.
- B. Use only those cleaning materials and methods recommended by manufacturer of the surface material to be cleaned.
- C. Use cleaning materials only on surfaces recommended by cleaning material manufacturer.

PART 3 – EXECUTION

3.01 Execution

- A. Execute periodic cleaning to keep the Work, the Project Site and adjacent properties free from accumulations of waste materials, rubbish, and windblown debris, resulting from construction operations.
- B. Provide on-site containers for the collection of waste materials, debris and rubbish.
- C. Dispose of waste materials debris and rubbish at designated dumping area on OWNER'S property upon approval from the OWNER.

3.02 Dust Control

- A. Dust control shall be in accordance with the Virginia Erosion and Sediment Control Handbook Standards and Specifications.

***** END OF SECTION *****

SECTION 017836

WARRANTIES

PART 1 – GENERAL

1.01 WORK INCLUDES:

- A. Compile any applicable manufacturer or third-party warranties.
- B. Co-execute submittals when so specified.
- C. Review submittals to verify compliance with the Contract.
- D. Submit to OWNER'S ENGINEER for review and transmittal and approval to OWNER.

1.02 SUBMITTAL REQUIREMENTS

- A. Assemble warranties and service and maintenance contracts, executed by each of the respective manufacturers, suppliers, and subcontractors.
- B. Number of original signed copies required: Two each.
- C. Table of Contents: Neatly typed, in orderly sequence. Provide complete information for each item.
 - 1. Product or work item.
 - 2. Firm, with name of principal, address, and telephone number.
 - 3. Scope.
 - 4. Date of beginning of warranty or service and maintenance contract.
 - 5. Duration of warranty or service maintenance contract if longer than requirements in the Contract.
 - 6. Provide information for OWNER's Personnel:
 - a. Proper procedure in case of failure.
 - b. Instances which might affect the validity of warranty.
 - 7. CONTRACTOR, name of responsible principal, address, and telephone number.

1.03 FORMS OF SUBMITTALS

- A. Prepare in duplicate packets.
- B. Format:

1. Size 8-1/2 in. x 11 in., punch sheets for 3-ring binder.
 - a. Fold larger sheets to fit into binders.
2. Cover: Identify each packet with typed or printed title "WARRANTIES". List:
 - a. Title of Project.
 - b. Name of Contractor.
 - c. Binders: Commercial quality, three-ring, with durable and cleanable plastic covers.

1.04 TIME OF SUBMITTALS

- A. For materials or component parts of the Work put into service prior to Project Completion:
 1. Submit documents within 10 days after inspection and completion of applicable portions of the Work.
- B. For material or component parts of the Work not put into service until Project Completion:
 1. Submit documents within Notice of Project Completion.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

NOT USED

***** END OF SECTION *****

SECTION 017839

PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.01 Summary

- A. The purpose of the final Record Documents is to provide factual information regarding all aspects of the Work, both concealed and visible, to enable future modification of the Work to proceed without lengthy and expensive Project Site measure, investigation, and examination.
- B. The CONTRACTOR shall maintain at the Project Site for the OWNER's permanent records one complete set of Record Documents which include a copy of the Contract Drawings, Contract Specifications, Addenda, Change Orders, Owner Field Orders, Shop Drawings, Quality Control Field Reports, Product Data, and Samples. The Contract Plans are to be used as Record Drawings by the CONTRACTOR.
- C. Submit three (3) bound sets of Record Drawings to the OWNER'S ENGINEER for submittal to OWNER upon the achievement of Project Completion. Employ the services of a licensed surveyor, licensed in the Commonwealth of Virginia, to prepare the Record Drawings.
- D. Clay liner, flexible membrane liner, and drainage/protection layer record drawings shall be provided by the OWNER's surveyor.

1.02 Submittals

- A. At Contract close-out, submit Record Documents to OWNER'S ENGINEER for the OWNER.
- B. Accompany submittal with transmittal letter in duplicate, containing:
 - 1. Date
 - 2. Project title and number
 - 3. Contractor's name and address.
 - 4. Title and number of each Record Document.
 - 5. Signature of Contractor or his authorized representative.

PART 2 – PRODUCTS

2.01 Record Drawings

- A. Record Prints: Maintain one set of blue or black-line white prints of the Drawings and Shop Drawings.
1. Preparation: Mark Record Prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is an installer, Subcontractor, or similar entity, to prepare the marked-up Record Prints.
 - a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
 - b. Accurately record information in an understandable drawing technique. Record data as soon as possible after obtaining it. Record and check the markup before enclosing concealed installations.
 2. Content: Types of items requiring marking include, but are not limited to, the following:
 - a. Dimensional changes to Drawings.
 - b. Revisions to details shown on Drawings.
 - c. Locations and depths of underground utilities.
 - d. Revisions to routing of piping and conduits.
 - e. Details not on the original Drawings.
 - f. Field records for variable and concealed conditions.
 3. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at the same location.
 4. Mark important additional information that was either shown schematically or omitted from original Drawings.
- B. Record Drawings: Immediately before inspection for Certificate of Substantial Completion, review marked-up Record Prints with OWNER'S ENGINEER and OWNER. When authorized, prepare a full set of corrected prints of the Contract Drawings.
1. Incorporate changes and additional information previously marked on Record Prints. Erase, redraw, and add details and notations where applicable.
- C. Format: Identify and date each Record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.

PART 3 – EXECUTION

3.01 Recording And Maintenance

- A. Recording: Maintain one copy of each submittal during the performance of the Work for Project Record Document purposes. Post changes and modifications to Project Record Documents as they occur; do not wait until the end of Project.

* * * * * END OF SECTION * * * * *

SECTION 022100

LINES AND GRADES

PART 1 – GENERAL

- A. All elevations indicated or specified refer to site datum. Control benchmarks are at the elevation and in the location as shown on the Contract drawings.
- B. From these established benchmarks run all lines and levels, furnish, set and drive grade stakes, and do all other work necessary to lay out work in accordance with the dimensions and elevations shown on the Contract drawings.
- C. Employ properly qualified personnel to perform the Work described. Provide all template and batter boards necessary. Preserve all stakes and marks established by the OWNER. If any of the stakes or marks are disturbed, the cost of replacing them shall be charged against the CONTRACTOR.
- D. Verify property boundary information and ensure that all Work is performed on the Project Site.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

NOT USED

* * * * * END OF SECTION * * * * *

SECTION 031100

CONCRETE FORMWORK

PART 1 - GENERAL

1.01 Description Of Work

- A. The CONTRACTOR shall furnish and install concrete formwork as required to form reinforced concrete for the concrete storm-water channel as shown and indicated on the Contract drawings, as specified herein, or as otherwise required to complete the Work.
- B. The CONTRACTOR shall comply with all Laws and Codes.

1.02 Related Sections

- A. Concrete Reinforcement – Section 032000
- B. Cast-in-place Concrete – Section 033000

1.03 Related References

- A. The latest edition of the publications listed below is included as a part of these Specifications.
 - 1. ACI 347 Recommended Practice for Concrete Formwork
 - 2. PS 1 US Department of Commerce Product Standard (PS) Construction and Industrial Plywood

1.04 Form Design

- A. The design of forms and their performance, as required by this Section, is the CONTRACTOR's responsibility. Formwork shall comply with ANSI A10.9 and OSHA Construction Standards, Part 1926, Subpart Q, Concrete, Concrete Forms, and Shoring.

PART 2 - PRODUCTS

2.01 Form Material

- A. Formwork for all concrete, unless otherwise specified, shall not be less than 5/8-inch, 5-ply plywood of exterior structural grade especially processed to resist moisture and conforming to PS 1, B-B Concrete Form Panels. Patented forms may be used, subject to approval by the OWNER'S ENGINEER and OWNER, provided they are in new, or like-new condition so as to produce a smooth, even surface free from blemishes, defects, and depressions; this approval is for the finish these forms will leave on the contact surfaces and will not relieve the CONTRACTOR of the responsibility for the design and structural soundness of the forms.

2.02 Accessories

- A. Form tie assemblies shall be form clamps with smooth tie rods, with a waterstop at the center, permitting tightening of the forms and be of such type as to leave no metal or other material within 1-1/2-inch of the surface after use. The assembly should provide cone-shaped depressions in the cast surface at least 1-inch in diameter and 1-1/2-inch deep to allow filling and patching.
- B. Form releasing agent shall be a non-staining form coating compound such as "Cast-Off" by Sonneborn Products Division (Contech, Inc.), or an equal product as approved by the OWNER'S ENGINEER and OWNER.

PART 3 - EXECUTION

3.01 Form Construction

- A. Formwork shall be in accordance with ACI 347 and as follows:
 - 1. Forms shall conform to shape, lines, and dimensions of members required and shall be sufficiently rigid and tight to prevent leakage of the cement binder. Forms shall be properly braced or tied together so as to maintain position and shape. Construct forms so that they can be removed readily without hammering or prying against the concrete. Forms for exposed concrete shall be carefully made and accurately placed to obtain correct shape and lines.
 - 2. Joints shall be butted tight on solid bearings. Arrangements of panels shall be orderly and symmetrical, and use of small pieces shall be avoided. Forms shall be chamfered for external corners of concrete, including top of walls, which will be exposed in the finished work.
- B. The CONTRACTOR shall be fully responsible for the adequacy of formwork in its entirety. Forms shall support the anticipated loading while maintaining their dimensional and surface correctness to produce members with the required geometry.
- C. Block-outs for slots, chases, recesses or other openings shall be provided by the CONTRACTOR as needed by the work of this and any other trades.
- D. Install all the inserts to be supported by the formwork as required by the work of this and other trades as needed.

3.02 Tolerance For Formed Surfaces

- A. Variation from Plumb: Not more than $\pm 1/4$ inch in any 10 feet of length with a maximum for the entire length of $\pm 1/2$ inch.
- B. Variation from the Level or from the Grades Specified in the Contract drawings: Not more than $\pm 1/4$ inch in any 10 feet of length with a maximum for the entire length of $\pm 3/4$ inch.
- C. Variation in the Sizes and Location of Openings and Thickness of Walls: $\pm 1/4$ -inch.

3.03 Inspection

- A. CONTRACTOR shall give the OWNER at least 48-hours notice before any concrete is to be cast. Concrete shall not be cast until the OWNER has observed and given approval of the Work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract.

3.04 Application Of Form Coating

- A. Immediately before the placing of reinforcing, faces of all forms in contact with the concrete shall receive a thorough coating of the liquid form-releasing agent specified, applied in compliance with the manufacturer's instructions.

3.05 Removal Of Forms

- A. The CONTRACTOR shall assume full responsibility for removal of formwork and forms shall be removed in such a manner as to ensure complete integrity and safety of the structure. Forms and shoring for mass concrete, walls, columns, and beams shall remain in place a minimum period of 7 Days after casting the concrete. Forms for slabs shall remain in-place a minimum of 24 hours after casting.
- B. Wood forms shall be completely removed from all concrete cast to avoid termite infestation.

* * * * * END OF SECTION * * * * *

SECTION 032000

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.01 Description Of Work

- A. CONTRACTOR shall furnish and install the concrete reinforcement as shown and indicated on the drawings, as required by these Specifications, and as specified in this Section.
- B. CONTRACTOR shall comply with all Laws and Codes.

1.02 Related Sections

- A. Cast-in-place Concrete – Section 033000

1.02 Referenced Publications

- A. The latest edition of the publications listed below are included as part of these Specifications.
 - 1. ACI 318 Building Code Requirements for Reinforced Concrete
 - 2. ACI 315 Manual of Standard Practice for Detailing Reinforced Concrete Structures
 - 3. ASTM A82 Specification for Cold Drawn Steel Wire for Concrete Reinforcement
 - 4. ASTM A185 Specification for Welded Steel Wire Fabric for Concrete Reinforcement
 - 5. ASTM A496 Deformed Steel Wire for Concrete Reinforcement
 - 6. ASTM A497 Welded Deformed Steel Wire Fabric for Concrete Reinforcement
 - 7. ASTM A615 Specification for Deformed and Billet-Steel Bars for Concrete Reinforcement

1.04 Submittals

- A. Shop Drawings to be submitted with the CONTRACTOR's detailed design submittal. Shop Drawings shall show the required bar sizes, spacing, and splice length for all reinforcement; reinforcement placing plans; and, bending details and complete bar lists. Shop Drawings will not be reviewed without such information. Wall reinforcing shall be shown in elevation. Location and arrangement of accessories shall be clearly indicated. Placing drawings, detail drawings and bar lists shall be checked by the fabricator and the CONTRACTOR before being submitted to the OWNER and OWNER'S ENGINEER for review.

PART 2 - PRODUCTS

2.01 Reinforcing Bars

- A. Bar reinforcement shall be deformed-type bars conforming to ASTM A615. Reinforcement shall be manufactured from new billet steel of American manufacture, Grade 60, yield strength 60,000 psi minimum.

2.02 Welded Wire Fabric

- A. Welded wire fabric shall be in flat sheets conforming to ASTM A185 (A497), with wire conforming to ASTM A82 (A496).

2.03 Accessories

- A. All chairs and bolsters shall have plastic-covered or galvanized steel legs.

PART 3 - EXECUTION

3.01 Storage Of Materials

- A. Reinforcing steel delivered to the Project Site shall be stored on clean, well-draining flat surface. All reinforcing steel shall be stored in bundles with tags. Reinforcing steel shall not be exposed to the elements.

3.02 Inspection Of Steel Placement

- A. CONTRACTOR shall give the OWNER at least 48-hours notice before any concrete is to be cast. Concrete shall not be cast until the OWNER has observed and given approval of the Work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract.

3.03 Tolerances

- A. Allowable tolerances for fabricating steel reinforcement shall be as follows:
 - 1. Sheared length of bars ± 1 inch

2. Location of bends ± 1 inch
- B. Allowable tolerances for placing steel reinforcement shall be as follows:
1. Concrete cover from outside of bar to finished surface $+ \frac{1}{4}$ inch
 2. Lateral spacing of bars in plane of reinforcement in slabs and walls ± 1 inch
 3. Height of bottom bars in slabs $\pm \frac{1}{4}$ inch
 4. Height of top bars in slabs $\pm \frac{1}{4}$ inch

3.04 Shop Fabrication

- A. Reinforcing steel shall be fabricated to required shapes and dimensions in compliance with applicable provisions of ACI 315 and ACI 318.
- B. Bars shall be bent cold. Bars shall be prefabricated to detail and delivered to the Project Site plainly tagged and ready to set.

3.05 Field Fabrication

- A. Field fabrication of reinforcing steel will not be permitted without the approval of the OWNER'S ENGINEER and OWNER.
- B. Field cutting of reinforcing steel shall be performed by shearing or abrasive cutting wheel. Cutting by flame is prohibited.

3.06 Placement And Anchorage

- A. Space metal chairs, bolsters, spacers and hangers in accordance with ACI 315.
- B. Reinforcement, at the time concrete is placed, shall be free from any abrasions or damage. Repairs shall be made immediately upon discovery.
- C. Reinforcement shall be accurately placed in accordance with the Shop Drawings and shall be adequately secured in position with not less than 16-gauge annealed wire or suitable clips at no less than 50% of the bar intersections. Reinforcement shall be held securely at the required distance from the forms. Nails shall not be driven into outside forms to support reinforcement.
- D. Install welded wire fabric reinforcement for concrete channels as indicated. Lap all joints 6-inches and wire securely. Extend mesh to within 2-inches of sides and ends of slabs. Unless otherwise specified, place welded wire fabric between the upper third-point and the mid-point of the slab. Sheets that do not lay flat when in their intended position will be rejected. Tags designating the wire size and spacing shall be left on each sheet until ready for use. Tuck ends of welded mesh well down into edge of beams or walls. Do not leave unreinforced border strips. Welded wire fabric shall not contain loose rust.

3.07 Concrete Cover

- A. Metal reinforcement shall be protected by concrete cover in accordance with ACI 318.

3.08 Splicing

- A. The location and type of splices desired by the CONTRACTOR must be specifically requested and must meet the approval of the OWNER'S ENGINEER and OWNER before they can be used.
- B. Splices shall not be made at point of maximum stress and shall provide sufficient lap to transfer stress between bars by bond.
- C. Splices in top reinforcement shall be made as shown of the reinforcement drawing and approved by the OWNER'S ENGINEER and OWNER.
- D. Mechanical splices may be used instead of lap splices provided that their location and type meets with the approval of the OWNER'S ENGINEER and OWNER.
- E. Splice locations shall be staggered with adjacent bars and bar bundles.

* * * * * END OF SECTION * * * * *

SECTION 033000

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 Description Of Work

- A. Furnish and install the cast-in-place concrete as shown and indicated on the Contract drawings and as specified in this Section, complete.

1.02 Related Sections

- A. Concrete Formwork – Section 031000
- B. Concrete Reinforcement – Section 032000

1.03 Referenced Publications

- A. The latest edition of the publications listed below form a part of these Specifications:
 - 1. American Concrete Institute (ACI) Publications
 - a. 211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
 - b. 301 Specifications for Structural Concrete for Buildings
 - c. 302.1R Guide for Concrete Floor and Slab Construction
 - d. 304 Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete
 - e. 305R Hot Weather Concreting
 - f. 306R Cold Weather Concreting
 - g. 318 Building Code Requirements for Reinforced Concrete
 - 2. ASTM International Materials Publications
 - a. C 31 Making and Curing Concrete Test Specimens in the Field
 - b. C 33 Concrete Aggregates
 - c. C 39 Compressive Strength of Cylindrical Concrete Specimens
 - d. C 94 Ready-Mixed Concrete
 - e. C 143 Slump of Portland Cement Concrete

- f. C 150 Portland Cement
- g. C 171 Sheet Materials for Curing Concrete
- h. C 172 Sampling Freshly Mixed Concrete
- i. C 173 Air Content of Freshly Mixed Concrete by the Volumetric Method
- j. C 231 Air Content of Freshly Mixed Concrete by the Pressure Method
- k. C 260 Air-Entraining Admixtures for Concrete
- l. C 309 Liquid Membrane-Forming Compounds for Curing Concrete
- m. C 494 Chemical Admixtures for Concrete
- n. C 595 Blended Hydraulic Cements
- o. C 618 Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
- p. C 881 Epoxy-Resin-Base Bonding Systems for Concrete

3. VDOT Road and Bridge Specifications, 2008 Edition.

1.04 Submittals

- A. Name and location of concrete suppliers.
- B. Concrete mix design indicating amount of all ingredients for each class of concrete to be used in the Work.

PART 2 - PRODUCTS

2.01 Cement

- A. Cement shall be standard Portland cement, conforming to ASTM C-150, Type I. Only one brand of commercial Portland cement shall be used in the exposed concrete of the structure. Cement reclaimed by cleaning bags or from leaking containers shall not be used.

2.02 Concrete Aggregates

- A. Fine aggregate shall be sand having clean, hard, durable, uncoated grains and free from deleterious substances and shall conform to ASTM C-33.
- B. Coarse aggregate shall be crushed stone having clean, hard, durable, uncoated particles conforming to ASTM C-33.

2.03 Water

- A. Water used in mixing concrete shall be clean, potable, and free from deleterious amounts of acids, alkalis, or organic materials.

2.04 Waterstops

- A. Where shown on the Contract Drawings in expansion joints and construction joints, waterstops shall be polyvinyl chloride (PVC) and shall incorporate a galvanized steel wire along both edges which shall be used to secure the waterstop in position, by tying to reinforcement, during concrete placement. The waterstop shall be of the size noted on the Contract Drawings. The waterstop shall be equal to Wirestop CR-9380 or Burke. The waterstop shall extend the entire length of the joint and all splices shall be heat welded and tested in accordance with the manufacturer's instructions.

2.05 Non-Shrink Grout

- A. Non-shrink grout shall be a ready-to-use non-metallic aggregate product requiring only the addition of water at the Project Site, and shall conform to COE CRD-C-621.

2.06 Admixtures

- A. Water reducing admixture shall conform to ASTM C-494, Type A.
- B. Water reducing, retarding admixture shall conform to ASTM C-494, Type D.
- C. Non-Corrosive, Non-Chloride Accelerator: The admixture shall conform to ASTM C-494, Type C.
- D. Air entraining admixture shall conform to ASTM C-260.
- E. High range water reducer (HRWR) shall conform to ASTM C494, Type F or G.
- F. Calcium Chloride: Calcium chloride or admixtures containing more than 0.1 percent chloride ions are not permitted.

2.07 Curing And Sealing Compounds

- A. Curing compound shall be acrylic based, conforming to ASTM C-309.
- B. Sealing-hardener compound shall conform to ASTM C-309.

2.08 Bonding Compounds

- A. Bonding Compound shall conform to ASTM 881.

PART 3 - EXECUTION

3.01 Concrete Quality

- A. All mix designs shall be proportioned in accordance with ACI 211.1. The proportioning shall be based on the requirements of a well-graded high density plastic and workable mix within the slump range and strengths required.
- B. Admixture Usage: All concrete shall contain a water reducing admixture or water reducing-retarding admixture, and an air entraining agent. All concrete placed at air temperatures below 50 degrees F shall contain the specified non-corrosive non-chloride accelerator.

3.02 Mix Designs

- A. Ready-mixed concrete shall be mixed and delivered in accordance with requirements of ASTM C-94 and to the following:
 - 1. A separate water metering device (not truck tank) shall be used for measuring water added to the original batch.
 - 2. Use of wash water as a portion of the mixing water is not permitted. Wash water added to empty drums after discharging shall be dumped before a new batch is received.
 - 3. Centrally mixed concrete shall be mixed for the length of time specified herein, not "shrink-mixed".
 - 4. Mixing drums shall be watertight.
 - 5. Concrete shall be discharged within one and a half hours from the time concrete was mixed, if centrally mixed, or from time the original water was added, if transit-mixed.
 - 6. Furnish delivery ticket with each load of concrete delivered under these Specifications. Delivery ticket shall show clearly the class and strength of concrete, size of coarse aggregate, water per cubic yard, the slump ordered, quantities of all admixtures, and the date and time of departure from the batching plant.

3.03 Conveying Equipment

- A. If concrete is to be transported in carts or buggies, the carts or buggies shall be equipped with pneumatic tires.
- B. Equipment for chuting or other methods of conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete at delivery without segregation of materials.

3.04 Conveying

- A. Concrete shall be conveyed from mixer to place of final deposit by methods which will prevent separation or loss of the material.

- B. Runway supports shall not bear upon reinforcing steel or fresh concrete.
- C. All conveying equipment shall be thoroughly cleaned before each run of concrete is begun.

3.05 Delivery And Protection Of Materials

- A. Deliver ready-mixed concrete in compliance with requirements set forth in ASTM C-94.

3.06 Severe-Weather Provisions

A. Hot-Weather Concreting

1. Provide adequate methods of lowering temperature of concrete ingredients so that the temperature of concrete when placed does not exceed 90 degrees F.
2. When the weather is such as to raise concrete temperature, as placed, consistently above 90 degrees F, Pozzoloth retarder shall be used.
3. Subgrade and forms shall be wetted with water before placing of concrete. All excess water shall be removed before concrete is placed.
4. Curing shall start as soon as practicable to prevent evaporation of water. Flat work shall be protected from dry winds, direct sun, and high temperatures.

B. Cold-Weather Concreting

1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather. No frozen materials, or materials containing ice, shall be used.
2. All concrete materials and all reinforcement, forms, fillers and ground with which concrete is to come into contact shall be free from frost.
3. Whenever the temperature of the surrounding air is below 40 degrees F and falling, all concrete placed in the forms shall have a temperature of between 70 and 80 degrees F, and adequate means shall be provided for maintaining a temperature of not less than 70 degrees F for three days, or 50 degrees F for five days, or for as much more time as is necessary to insure proper curing of the concrete. If high early strength concrete is used, the requirement for maintenance of 50 degrees F can be reduced to three days.
4. Use only the specified non-chloride accelerator. Calcium chloride or admixtures containing more than 0.1 percent chloride ions are not permitted.
5. Housing, covering, or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heat is discontinued.

3.07 Construction Joints And Expansion Joints

- A. Construction Joints: Early in the construction program, the CONTRACTOR shall review with the OWNER and OWNER'S ENGINEER any construction joints proposed for use which are not indicated on the Contract Drawings. The CONTRACTOR shall not use any construction joints which are not approved by the OWNER and OWNER'S ENGINEER. In all cases, construction joints shall occur at sections of minimum shear. Where construction joint is to be made, surface of the concrete shall be roughened (construction joints detailed with key ways in slabs and walls, are not required to be roughened) and thoroughly cleaned of foreign matter and laitance. In addition to the foregoing, joints shall be dampened with water and the specified bonding compound applied, or a slush coat of neat cement grout shall be applied. Additional construction joints that are requested by the CONTRACTOR and approved by the OWNER and OWNER'S ENGINEER shall be of the type shown and/or noted on the Contract Drawings for the specific element(s) being considered (i.e., wall slabs, etc.).

3.08 Waterstops

- A. Waterstops shall be installed as indicated and noted on Contract drawings.

3.09 Inspection Of Working Before Placing

- A. The CONTRACTOR shall inspect the forms to receive concrete for any deficiencies which would prevent proper placing of concrete. Do not proceed with placing concrete until such deficiencies are corrected.
- B. Give the OWNER and CQA Consultant at least 48 hours notice before any concrete is to be cast. Concrete shall not be cast until the CQA Consultant has observed and given approval of the work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract.
- C. Do not place concrete on earth until the fill or excavation has been prepared as set forth under applicable Sections of the Specifications for that Work.
- D. The CONTRACTOR shall not place in the concrete any item that is not authorized to be placed by the Contract Drawings and Specifications. The CONTRACTOR shall insert all the items as required by the other trades and properly position and secure them in their intended location. Openings other than those which are facilitated by sleeves shall be properly formed and positioned as required by the other trades.
- E. Do not place concrete in forms until all foreign matter has been removed from forms and the reinforcing steel is in proper condition for placement of concrete.
- F. Remove hardened, or partially hardened, concrete on forms or reinforcement before placing concrete.

3.10 Placing

- A. Deposit concrete as nearly as practicable in its final position to avoid segregation due to re-handling or flowing. Do not deposit concrete on work that has partially hardened or been contaminated by foreign material, and do not use re-tempered concrete.
- B. Concrete shall be placed to avoid the displacement of reinforcing, and coating or spattering the reinforcing steel. The placing of concrete within form work shall be regulated so that the pressure within form work does not exceed the design pressure. In placing concrete, each layer shall be placed following the preceding layer to prevent lines of separation or "cold joints" in the work. After the concrete reaches its initial set, jarring the formwork or placing strain or vibration on the ends of projecting reinforcing bars shall be carefully avoided.
- C. Concrete shall not be dropped more than four feet. For greater distances of drop, concrete shall be handled with metal chutes or tremie pipes.
- D. Once concreting is started, it shall be carried on as a continuous operation until placing of the concrete between construction joints is completed. The top surface will be finished to the required alignment.
- E. Concrete shall be placed in layers not over 12-inches deep and each layer shall be compacted with the aid of mechanical internal-vibrating equipment supplemented by hand spading. Vibrators shall in no case be used to transport concrete. Use of form vibrators will not be permitted. Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the concrete. Duration of vibrator use shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation. Vibrator shall not be lowered into courses that have begun to set. Apply vibrator at uniformly spaced points not further apart than the visible effectiveness of the machine.
- F. Type and use of vibrators shall be in accordance with ACI 301.

3.11 Protection

- A. Protect freshly placed concrete from damage or injury due to water, falling objects, persons or anything that may mar or injure finish surface on concrete. Only light use of any floors shall be permitted for the first seven days after placing of concrete.

3.12 Curing

- A. All concrete, after placement and finishing, shall be maintained in a moist condition for at least seven successive days during which the temperature of the concrete is 50 degrees F or above. For temperatures of 50 degrees F and below, curing period shall be 14 successive days.
- B. Concrete shall be kept moist by any one, or combination, of the following methods:
 - 1. Ponding or Immersion: Continually immerse the concrete in water throughout the curing period. Lowest temperature water shall not be more than 20 degrees F colder than the temperature of the concrete.

2. Fog Spraying or Sprinkling: Provide uniform and continuous application of water throughout the curing period.
 3. Impervious Sheeting: Wet the entire exposed surface of the concrete thoroughly with a fine spray of water and cover with impervious sheeting throughout the curing period. Lay sheeting directly on the concrete surface and overlap edges 12-inches minimum. Provide sheeting not less than 18-inches wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheeting or provide new sheeting. Inspect surface of concrete daily for wetness. The surface shall be kept continuously wet during the curing period.
- C. Concrete in Formed Surfaces - Keep forms and exposed surfaces wet with water during the curing period. If forms are removed before the end of the curing period, apply a curing compound within one hour after form removal.

3.13 Patching

- A. Any concrete which is not formed as shown on the Contract drawings, or for any reason is out of alignment or level or shows a defective surface, or shows defects which reduce the structural adequacy of a member or members, as determined by the OWNER and OWNER'S ENGINEER, shall be considered as not conforming with these Specifications and shall be removed from the Project by the CONTRACTOR at CONTRACTOR's own expense, unless the OWNER and OWNER'S ENGINEER grants permission to patch the defective area, which shall be done in accordance with the following procedure:
1. After removing the forms, all concrete surfaces shall be inspected and any joints, voids, stone pockets or defective areas permitted by the OWNER and OWNER'S ENGINEER to be patched and all tie holes, shall be patched. Defective areas shall be chipped away to a depth not less than 1-inch with the edges perpendicular to the surface. Remove defective areas to sound concrete with clean, square cuts. Dampen concrete surfaces to be in contact with patching concrete and apply the specified bonding compound. Place patching concrete over the bonding compound as specified by the manufacturer. Place, compact and finish to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.
- B. Patching material shall be mixed, applied, and cured as per the manufacturer's specifications. The patch shall be finished to match the adjoining surface.
- C. Tie holes left by withdrawal of rods or the holes left by removal of ends of wall ties shall be filled solid with mortar after first being wetted. For holes passing through the wall, a plunger-type grout gun shall be used to force the mortar through the wall starting at the back face. A piece of burlap or canvas shall be held over the hole on the outside and when the hole is filled, the excess mortar shall be struck off with the cloth flush with the surface. Holes not passing through the walls shall be filled with a small tool that will permit packing the hole solid with mortar. Any excess mortar at the surface of the wall shall be struck off flush with a cloth.

3.14 Surface Finishes

- A. Upon completion of patching, surfaces of concrete shall be finished as follows:
1. Broom finish shall be produced on all horizontal surfaces intended to receive foot traffic, such as floors and stoops.
 2. Common finish shall be produced by filling all tie holes, honeycomb and depressions, and knocking off and evening up burrs and form marks. All concrete surfaces not receiving a broom or rough finish shall receive a common finish.
 3. Rough finish shall be produced by filling all tie holes and honeycomb and in other respects leaving the surface as formed. All concrete surfaces which will be covered by earth and which will not be visible in the completed structure, shall receive a rough finish.

3.15 Non-Shrink Grout

- A. All applicable locations noted on the Contract drawings or in these Specifications shall be grouted with the specified non-shrink, non-metallic grout.

3.16 Quality Control

- A. The CONTRACTOR shall be solely responsible for the quality control testing and sampling of all concrete and shall retain an independent testing laboratory to conduct testing of the concrete for slump, air content, and compression. The CONTRACTOR is responsible to provide test results to the OWNER AND OWNER'S ENGINEER.
- B. Concrete which does not meet the requirements of these specifications may be rejected by the OWNER and OWNER'S ENGINEER, and shall be removed and replaced at the CONTRACTOR's expense.

* * * * * END OF SECTION * * * * *

SECTION 034000

PRE-CAST CONCRETE STRUCTURES

PART 1 - GENERAL

1.01 Description Of Work

- A. CONTRACTOR shall furnish all Materials and Equipment, labor, Construction Aids, tools, and appurtenances required to construct the valve vault and cleanout vault as described herein and/or shown on the drawings.
- B. Comply with all Laws and Codes.

1.02 Related Sections

- A. Concrete Reinforcement – Section 032000
- B. Cast-in-place Concrete – Section 033000
- C. Earthwork – Section 310000

1.03 Design Requirements

- A. Pre-cast concrete valve vault and cleanout vault shall be constructed of specified materials to the sizes, shapes, and dimensions and at the locations shown on the drawings or as otherwise directed and approved by the OWNER and the OWNER'S ENGINEER.

1.04 Submittals

- A. Complete shop drawings and engineering data on precast concrete structures shall be submitted to the OWNER and CQA Consultant.
- B. CONTRACTOR shall submit to OWNER and CQA Consultant detailed drawings showing layout of components and appurtenances contained within pre-cast concrete structures. The pre-cast concrete structure layout drawings shall have dimensional callouts and show:
 - 1. Equipment
 - 2. Wall penetrations
 - 3. Piping and supports
 - 4. Manway openings/covers including fastening and sealing mechanism
 - 5. Rungs
- B. Separate submittals for the equipment to be installed or mounted on the structures shall be submitted at the same time as the submittals related to the vaults as described in the above paragraphs and other applicable Sections.

1.05 Quality Assurance

- A. Prior to delivery, all basic materials specified herein shall be tested and inspected by an approved independent commercial testing laboratory or, if approved by the OWNER, certified copies of test reports prepared by the manufacturer's testing laboratory will be acceptable. All materials which fail to conform to these Specifications shall be rejected.
- B. After delivery to the Project Site, any materials which have been damaged in transit or are otherwise unsuitable for use in the Work shall be rejected and removed from the Project Site at no cost to the OWNER.

PART 2 - PRODUCTS

2.01 Materials And Construction

- A. Concrete and Reinforcement
 - 1. Concrete used shall be Class A4 (General) concrete conforming to the requirements of Section 03120 of these Specifications.
 - 2. Steel reinforcement shall conform to the requirements of Section 03120 of these Specifications.
- B. Mortar: Mortar for vault construction shall be sand-cement mortar composed of one part Portland cement to two parts clean sand conforming to ASTM C144.
- C. Pre-cast Concrete Vaults
 - 1. Pre-cast concrete vaults shall consist of pre-cast reinforced concrete sections, a flat slab top section, and a base section conforming to the typical vault details as shown on the drawings.
 - 2. Pre-cast vaults section shall be manufactured, tested, and marked in accordance with the latest provisions of ASTM C478.
 - 3. The minimum 28-day compressive strength of the concrete for all sections shall be 4,000 psi.
 - 4. The maximum allowable absorption of the concrete shall not exceed eight percent of the dry weight.
 - 5. The reinforcement in the riser sections, top sections and base wall sections shall consist of one line of steel and shall be not less than 0.17 square inch per lineal foot.
 - 6. The ends of each reinforced concrete vault riser section and the bottom end of the vault top section shall be so formed that when the vault risers and the top are assembled, they will make a continuous and uniform vault.

7. Joints of the vault sections shall be of the tongue and groove type. Sections shall be joined using rubber gaskets conforming to the applicable provisions of ASTM C443, latest revision, or filled with an approved preformed plastic gasket meeting the requirements of Federal Specifications SS-S-00210, "Sealing Compound, Preformed Plastic for Pipe Joints", Type 1, Rope Form.
8. Each section of the pre-cast vault shall have no more than two holes for the purpose of handling and laying. These holes shall be tapered and shall be plugged with rubber stoppers or mortar after installation.

D. Hatches and Steps

1. Valve vaults shall be accessed with a minimum 40" by 40" aluminum locking access hatch located as shown on the drawings.
2. Cleanout vault shall be accessed with a minimum 24" by 24" aluminum locking access hatch located as shown on the drawings.
3. Vault steps shall be polypropylene coated grade 60 reinforcing bar, conforming to the applicable provisions of ASTM Standard Specification Serial Designation C478 and shall be accessible from the hatch opening.

E. Wall Penetration Seal

1. Wall penetration seal for pre-cast concrete vaults shall be expandable rubber link type, water tight and rated for corrosive service. Bolts, Nuts and Bands shall be 304 Stainless Steel. Pressure plates shall be Glass Reinforced nylon. Rubber shall be EPDM.
2. Wall penetration seal shall be certified by the manufacturer to be compatible between the approved pre-cast concrete structure and piping to provide a water tight seal when installed in accordance with the manufacturer's installation procedures.

PART 3 - EXECUTION

3.01 Construction Of Pre-Cast Concrete Vaults

- A. Prior to placing the pre-cast concrete structures, a minimum 12-inch thick layer of Maryland Department of Transportation No. 57 stone shall be placed as a level bedding for the structures.
- B. After the base section has been set, the pre-cast concrete sections shall be placed thereon, care being exercised to form the pipe connections at the required elevations.
- C. The hatches for the vaults covers shall be set at the required elevation and properly anchored to the masonry.

***** END OF SECTION *****

SECTION 036100

CEMENTITIOUS GROUTING

PART 1 - GENERAL

1.01 Description Of Work

- A. CONTRACTOR shall furnish and install the grout mixtures as shown and indicated on the Drawings, as required by this Scope of Work, the Contract, these Specifications, and as specified in this Section. CONTRACTOR shall provide a competent person to implement, supervise, and inspect all Work.
- B. CONTRACTOR shall comply with all Laws and Codes.

1.02 Related Sections

- A. Pipe Abandonment – Section 330505

1.02 Reference Publications

- A. The latest edition of the publications listed below are included as part of these Specifications.
 - 1. ACI 301 Specifications for Structural Concrete
 - 2. ACI 318 Building Code Requirements for Reinforced Concrete
 - 3. ASTM C33 Standard Specification for Concrete Aggregates
 - 4. ASTM C94 Standard Specification for Ready-Mixed Concrete

1.04 Submittals

- A. CONTRACTOR shall provide copies of the grout mix designs and supporting documentation showing conformance to this specification and the above referenced publications.
- B. CONTRACTOR shall provide documentation for all grout mix components, including selected admixtures. This documentation should include batch tickets for pre-mixed grout.

PART 2 - PRODUCTS

2.01 Low-Strength Grout

- A. Low-strength grout mixes shall provide a minimum design strength of 300 psi. This grout mix is intended for applications, such as pipe abandonment, where the grout is not expected to provide structural reinforcement.

- B. Low-strength grout shall be non-shrink.

2.02 Medium-Strength Grout

- A. Medium-strength grout mixes shall provide a minimum design strength of 1200 psi. This grout mix is intended for applications, such as manhole or pipe installation, where the grout is expected to require low amounts of structural support.
- B. Medium-strength grout shall be non-shrink.

2.02 Cement

- A. Cement shall be Type I/II low-alkali Portland cement capable of being used in a CCR environment.

2.02 Aggregate

- A. Grout aggregate shall be clean sand conforming to the requirements of ASTM C33. CONTRACTOR shall provide supporting documentation showing a sieve analysis of the proposed aggregate.

2.03 Grout Admixtures

- A. The use of CCR materials (fly ash, bottom ash, etc.) as an admixture is not allowed in grout applications where the grout will come in contact with groundwater or will experience prolonged exposure to stormwater (i.e. sediment basins).
- B. Air entrainment admixtures should be used in accordance with manufacturer specifications.
- C. Additional admixtures for hot/cold installation, etc. may be used as allowed by OWNER.

PART 3 - EXECUTION

3.01 Storage Of Materials

- A. Grout may be mixed on-site or may be pre-mixed.
- B. If grout is prepared on-site, grout mixture materials, such as sand, shall be stored on clean, well-draining flat surfaces. Cement shall be stored in a fashion that minimizes exposure to moisture.
- C. If pre-mixed grout is used, it shall be stored in accordance with manufacturer specifications.

3.02 Grout Mixture Requirements

- A. Grout mixtures shall adhere to the following minimum properties:

Property	Low-Strength	Medium-Strength
Strength (psi)	300	1200
Slump (in)	6 - 8	6 - 8
Air Entrainment	8%	8%

- B. Slump testing shall be performed by the CONTRACTOR prior to placement for every mix, and shall be documented by a competent person.
- C. CONTRACTOR shall furnish copies of grout mixture testing as part of the grout submittal package (see 1.04).

* * * * * END OF SECTION * * * * *

SECTION 310000

EARTHWORK

PART 1 – GENERAL

1.01 Work Included

- A. The work under this section includes the furnishing of all labor, equipment and materials, and completing all operations in connection with excavating, backfilling, compacting, grading, and placing soil materials and all other incidental work necessary for construction according to Contract drawings and technical Specifications.
- B. The CONTRACTOR shall comply with all Laws and Codes.
- C. The CONTRACTOR shall locate all existing active and abandoned utilities and structures in work areas prior to commencing any excavation activities and shall protect from damage those utilities and structures which are to remain in place

1.02 Related Work

- A. Carefully examine the Contract for requirements affecting the Work of this section.
- B. Other specification sections containing requirements relating to this section include, but are not limited to, the following:
 - 1. Temporary Erosion and Sediment Control – Section 015713
 - 2. Coarse Aggregate – Section 310516
 - 3. Construction Dewatering – Section 312319
 - 4. Vegetative Support Layer – Section 329119

1.03 Definitions

- A. Excavation shall mean the removal from place of all materials and shall include soil, facilities, structures above and below ground, rock, pavements, topsoil, boggy waste, rubbish, tree stumps, boulders, logs, ashes, cinders, organic material such as peat, humus or organic silt, softened or disturbed soils or other unsuitable bearing materials determined in the field by the OWNER'S Representative or his designee.
- B. Mucking or mucking-out shall mean excavation, as defined herein before, without prior dewatering.

1.04 Protection of People And Property

- A. The CONTRACTOR shall plan and conduct operations in accordance with Laws and Codes, including OSHA and local codes and ordinances, so as to prevent damage to existing structures, safeguard people and property, minimize traffic inconvenience, protect the structures to be installed, and provide safe working conditions.
- B. The CONTRACTOR shall control stormwater such that run-on and run-off do not affect the quality of receiving wetlands, brooks, streams, or rivers. The CONTRACTOR shall be responsible for cleaning (removal of silt) stormwater structures (swales, culverts, basins) as needed during construction, after stabilization of project areas, and at the conclusion of Work prior to Demobilization.
- C. The CONTRACTOR shall be responsible for protecting existing environmental monitoring devices such as groundwater monitoring wells within the limits of work. Any damage to existing environmental monitoring devices resulting from construction activities shall be the responsibility of the CONTRACTOR to correct at no additional cost to the OWNER.
- D. Excavations, except as specified, shall be adequately shored and braced. Where the installation of shoring is impractical or might cause damage, as a result of, but not limited to, vibration, settlement or lateral movement, the CONTRACTOR shall utilize other methods.
- E. CONTRACTOR shall be solely responsible for proper excavation procedures including, but not limited to, safe slope angles and the design and use of properly designed and installed shoring and bracing systems in accordance with Laws and Codes, including OSHA and other applicable standards and requirements. As required, shoring and bracing shall be designed by the CONTRACTOR's engineer who is a registered Professional Engineer in the Commonwealth of Virginia. Remove all shoring and bracing without disturbing backfill, bedding, haunching, pipes or structures. The presence of the OWNER'S ENGINEER and OWNER shall not relieve the CONTRACTOR of his responsibility to properly design, install and maintain shoring and bracing.
- F. In cases where excavation without shoring and bracing is not permissible solely because of protection of workers, trench boxes may be used.
- G. The CONTRACTOR shall not stockpile any excavated material without OWNER approval. Stockpile location shall be approved by the OWNER'S ENGINEER and OWNER.

1.05 References

- A. ASTM D6913 Standard Test Methods for Particle Size Distribution (Gradation) of Soils Using Sieve Analysis
- B. ASTM D698 Laboratory Compaction Characteristics of Soil Using Standard Compaction Effort
- C. ASTM D2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- D. ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

- E. ASTM D422 Standard Test Method for Particle Size Analysis of Soils
- F. ASTM D3080 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
- G. ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.06 Submittals

A. Shoring and Bracing

1. In cases where the excavation cannot be open cut to a safe working angle in accordance with applicable requirements or where excavation may jeopardize adjacent site areas or the stability of nearby structures or facilities, the CONTRACTOR shall submit drawings, computations and substantiating data, prepared, signed, and sealed by a professional engineer licensed in the Commonwealth of Virginia, showing his proposed shoring and bracing design and method of construction for the information of the OWNER prior to the start of such construction.
2. Shoring and bracing systems shall be designed such that removal shall not jeopardize work already performed. Shoring and bracing systems shall not remain permanently in place without the written approval of the OWNER.
3. Any review or comments by the OWNER shall not relieve the CONTRACTOR of his responsibility for sheeting and bracing.
4. In trenches, the sheeting shall be designed so that the lowest brace is no closer than 12 inches above the base of the structure to be installed.

B. The CONTRACTOR shall submit the technical data sheet for the proposed compaction equipment to the OWNER and OWNER'S ENGINEER for review and approval.

C. The CONTRACTOR shall provide the OWNER and OWNER'S ENGINEER samples from each borrow source to be used as structural fill. From each borrow source, representative composite sample(s) shall be tested for the following:

1. Soil Classification (ASTM D2487, which includes Grain Size Analysis - ASTM D422 (or D6913) and Atterberg Limits - ASTM D4318); two per source or material type
2. Compaction Testing (Proctor) (ASTM D698); two per source or material type

D. If the OWNER and OWNER'S ENGINEER determines that the source contains more than one soil type, as determined by the Unified Soil Classification System (USCS), the tests listed shall be completed for each soil type.

1.07 Tolerances

- A. Grading tolerance for all fill and backfill shall be ± 0.1 feet.

1.08 Quality Assurance

- A. The CONTRACTOR shall be an experienced earthwork CONTRACTOR who has at least five years of experience. The CONTRACTOR shall have completed at least three projects with the same material and of similar scope as that indicated for this project with a successful installation and maintenance record of in-service performance.
- B. The CONTRACTOR is required to demonstrate compliance to the above requirements to the satisfaction of the OWNER'S ENGINEER and OWNER.

PART 2 – PRODUCTS

2.01 Materials

- A. All backfill and fill materials, unless otherwise specified, shall consist of suitable, selected, and approved (by the OWNER) soil from borrow areas.
- B. The Liner Subgrade shall consist of the top six inches of material underlying a geomembrane liner. Liner Subgrade shall contain particles no larger than 1/2" in their greatest dimension (unless otherwise approved by the OWNER and OWNER'S ENGINEER) and be free of organic materials. Liner Subgrade materials shall consist of soil materials having a USCS classification of SC, ML, CL, MH, CH, or Coal Combustion Residual (CCR). Soil containing CCR may be used as structural fill in areas that will be covered by the geomembrane liner.
- C. No frozen earth shall be used for backfill and fill, and no fill or backfill shall be placed over frozen surfaces. All backfill and fill materials shall be free from all perishable and objectionable (as described below) materials. All fill shall be protected from frost if the OWNER'S ENGINEER or OWNER judges frost will prevent the material from performing as required.
- D. All required fill materials shall be free from organic materials, wood, trash, and other objectionable materials which may be compressible or which cannot be properly compacted. It shall not contain rock fragments, broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and compacted to the specified density. Snow, ice, and frozen soil shall be removed from fill material prior to placement.
- E. Remediated contaminated soil shall not be permitted as backfill or fill material.

2.02 Structural Fill

- A. Structural fill materials shall be used as subgrade fill, clean backfill, pipe bedding, and as other material as shown on the Drawings. Structural fill shall be free of rubble, wood, stumps, brush, metal, cinders, trash, demolition debris, garbage, topsoil, organic soil, loam, sludge and other deleterious materials. The maximum stone size shall be two inches in any dimension and shall not comprise more than five percent of the total soil mass. Structural fill materials shall be classified according to the USCS as GM, GC, SM, SC, ML, CL, MH or CH (ASTM D2487). Structural fill shall be approved by the OWNER'S ENGINEER and OWNER for each application. Soil containing CCR may be used as structural fill in areas that will be covered by geomembrane liner.
- B. The interface friction angle between the liner subgrade and the HDPE geomembrane shall be greater than or equal to 24° as determined by ASTM D5321 or as approved by the OWNER'S ENGINEER. Each test shall determine interface strength at normal stresses of 100 pounds per square foot (psf), 300 psf, and 500 psf. The interface shear test shall be completed using installation procedures used under actual field conditions. Tests shall be completed under fully saturated conditions (saturation time of 15 minutes), have a seat time of 15 minutes, and have a shear rate of 0.04 inches per minute (in/min). Additional samples shall be collected and tested if the material does not meet the minimum requirements of this technical specification.

2.03 Protective Cover Layer

- A. Fill for the Protective Cover Layer shall consist of soil material that is void of deleterious materials and has no particles over 1 inch in their greatest dimension (unless otherwise approved by the OWNER'S ENGINEER and OWNER). Under no circumstances will CCR or CCR mixed with soil be used as Protective Cover Layer material.

2.04 Vegetative Support Layer

- A. Fill for the Vegetative Support Layer shall consist of soil material that is void of deleterious materials, has no particles over 1-inch in their greatest dimension (unless otherwise approved by the OWNER'S ENGINEER and OWNER) and meets the requirements of Section 329119 of the Technical Specifications. Under no circumstances will CCR or CCR mixed with soil be used as Vegetative Support Layer material.

PART 3 – EXECUTION

3.01 Preparation

- A. The CONTRACTOR shall establish and identify required lines and levels.
- B. The CONTRACTOR shall maintain benchmarks, monuments, and other reference points and reestablish them if disturbed or destroyed, at no cost to OWNER.
- C. Before start of grading, the CONTRACTOR shall establish the location and extent of utilities in the work areas. The CONTRACTOR shall notify utilities to remove and relocate lines that are in the way of construction and are not to be relocated as a part of the work covered by these specifications.

- D. The CONTRACTOR shall maintain, protect, reroute, or extend as required existing utilities to remain in place that pass through the work area.
- E. The CONTRACTOR shall develop access to the construction area in accordance with the requirements of the drawings.
- F. The CONTRACTOR shall install silt fences as needed to prevent erosion immediately downslope of each area to be disturbed prior to the beginning of work in that area. The CONTRACTOR shall maintain the silt fences for the duration of construction. Accumulated sediment behind the silt fences shall be disposed of on-site by the CONTRACTOR in a manner approved by the OWNER.
- G. Diversion ditches, either permanent or temporary, shall be constructed in accordance with the drawings and as necessary to control surface water. The CONTRACTOR shall be responsible for constructing diversion ditches as required to divert run-on around the construction area and maintain the diversions until approved by the OWNER and OWNER'S ENGINEER.
- H. The CONTRACTOR shall install barriers and other devices to protect areas adjacent to construction.

3.02 Stripping and Stockpiling

- A. Stripping of existing cover soil materials shall take place under observation of the CQA Consultant to identify areas where CCR has been disturbed and mixed with the overburden soils. When CCR is discovered, the material shall be segregated placed in a CCR-mixed soil stockpile area. CCR-mixed soils may be used as structural fill in areas that will be covered with a geomembrane liner; however CCR-mixed soils shall not be used as final protective cover (2.03) or vegetative support layer (2.04) materials.
- B. Excavated materials classified suitable for use as structural fill shall be stockpiled in designated areas free of incompatible soil, clearing debris, or other objectionable materials. Stockpile areas shall be approved by the OWNER.
- C. Excavated material classified as topsoil shall be segregated from fill and stockpiled in the manner shown on the Drawings or as specified by the OWNER.
- D. Stockpiles of fill or topsoil shall be no steeper than 3:1 (horizontal:vertical), graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the OWNER'S ENGINEER and OWNER, and dressed daily during periods when fill is taken from the stockpile.

3.03 Excavation - General

- A. Excavation shall be performed, at a minimum, to the lines and grades indicated on the Drawings. Additional excavation shall only be performed to achieve a stable working base or to "bridge" over weak subgrade materials if approved by the OWNER'S ENGINEER and OWNER. The limits of additional excavation shall be determined by the OWNER'S ENGINEER and OWNER.

- B. Excavated materials shall be transported to stockpile or placement locations, as indicated on the Contract drawings or as directed by the OWNER.

3.04 Grading - General

- A. Uniformly grade areas to a smooth surface, free of irregular surface changes, to the lines and grades indicated on the Contract drawings. Provide a smooth transition between existing grades and new grades.
- B. Unless otherwise specified, place borrow fill and trench backfill material in lifts of not more than nine inches in compacted depth for material compacted by heavy construction equipment, and not more than four inches in loose depth for material compacted by hand-operated tampers. Compact borrow fill and trench backfill material as specified in Section 3.06.B.

3.05 Trench Excavation And Backfill

- A. Excavation for all drainage, piping, and other structures shall conform to the lines and grades shown on the construction drawings. Excess or unsuitable material removed from the excavations shall be replaced with approved material. The CONTRACTOR will be responsible for all shoring, bracing, trench boxes, etc., necessary to complete the excavation and pipe installation in a safe manner.
- B. Stability of Excavations: Slope sides of excavations shall comply with Laws and Codes, including OSHA. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Comply with all OSHA and other applicable safety requirements.
- C. Unless directed otherwise by the OWNER and OWNER'S ENGINEER, excavations shall not be backfilled until the work as installed conforms to all requirements specified in these technical Specifications. Each lift of trench backfill material shall be moistened as necessary and compacted in such a manner as to permit the proper and desired compaction of the filled excavation to provide the necessary support and protection for the pipe.
- D. Placement of pipe bedding shall be done in accordance with the following procedures.
 - 1. The bottoms of excavations shall be thoroughly compacted and in an approved condition prior to placing pipe bedding. Pipe bedding shall be placed in layers not exceeding four inches in loose depth. Each layer shall be compacted by at least two passes of an approved plate-type vibratory compactor.
 - 2. Pipe bedding shall be graded, compacted, and shaped so that the full length of pipe barrel has complete and uniform bearing for the bottom quadrant of each pipe.

3. The CONTRACTOR shall exercise care in all operations to prevent disturbing joints, displacement of or damage to the pipes already installed, and tearing of geotextile. As the work progresses, the pipelines will be checked by the OWNER and OWNER'S ENGINEER to determine whether any disturbance, displacement, or damage has occurred. If inspection shows poor alignment, displaced or damaged pipe, disturbed joints, or any other defects, all defects designated by the OWNER and OWNER'S ENGINEER shall be remedied in a satisfactory manner by the CONTRACTOR, at no additional expense to the OWNER.
- E. The balance of backfill, as shown on the Drawings and specified in this section, shall be structural fill or other compactable materials as approved by the OWNER and OWNER'S ENGINEER and as detailed. All trench backfilling shall be carefully placed to avoid disturbance of new work.
- F. Backfill trench with clean backfill in accordance with the details shown on the Drawings. Place backfill material by hand, and compact in layers not exceeding six inches compacted thickness. The moisture content of backfill shall be such that proper compaction will be obtained. Backfill shall be compacted to the minimum requirements specified. It is the responsibility of the CONTRACTOR to ensure that the minimum specified densities are obtained. Puddling or jetting of backfill with water will not be permitted.
- G. Compact soil materials using equipment suitable for materials to be compacted and work area locations. Hand-operated plate type vibratory or other suitable equipment may be used in areas not accessible to larger rollers or compactors, and to avoid damaging pipes or structures. Any pipe that is damaged shall be replaced at the CONTRACTOR's expense.
- H. Backfill material shall be compacted to achieve the compaction specified in Section 3.06.B.
- I. During filling and backfilling operations, pipelines will be checked by the OWNER and OWNER'S ENGINEER to determine whether any displacement of the pipe has occurred. If the inspection of the pipelines shows poor alignment, displaced pipe or any other defects, the defects designated by the OWNER and OWNER'S ENGINEER shall be remedied in a satisfactory manner by the CONTRACTOR at no additional expense to the OWNER.
- J. Any backfill that fails to comply with the minimum compaction requirements specified shall be recompacted or, if necessary, removed to the limits directed by the OWNER and OWNER'S ENGINEER. The trench shall then be refilled with approved materials and by approved methods. The backfill shall be compacted by approved methods to the minimum requirements specified. All of this work shall be completed by the CONTRACTOR at no additional expense to the OWNER.

- K. After backfilling, the CONTRACTOR shall maintain the filled surfaces in good condition with a smooth surface level with adjacent undisturbed surfaces. Any subsequent settling shall be immediately repaired by the CONTRACTOR in a manner satisfactory to the OWNER and OWNER'S ENGINEER. Such maintenance shall be provided by the CONTRACTOR for the remainder of this contract at no additional expense to the OWNER.
- L. Anchor Trenches
1. CONTRACTOR shall excavate anchor trenches, unless otherwise specified, to lines and grades shown on design construction drawings prior to geomembrane placement. Anchor trench shall be drained to prevent ponding or softening of adjacent soils while trench is open.
 2. Slightly rounded corners shall be provided in the anchor trench to avoid sharp bends in geomembrane.
 3. If the anchor trench is excavated in clay material susceptible to desiccation, the amount of trench open at any time should be minimized.
 4. Remove construction-related debris from anchor trench.
 5. Earthwork Contractor shall backfill and compact anchor trench as soon as practical after geomembrane installation is completed. Take care when backfilling trenches to prevent damage to geosynthetics.

3.06 Structural Fill

A. Subgrade Preparation

1. Prepare areas to receive structural fill by:
 - a. Clearing and grading areas required for access to site and execution of the Work. Clearing shall be limited to areas within the limits of construction that need to be cleared in order to execute the Work.
 - b. Grubbing areas within a 10-foot zone bordering all proposed structures and pipelines.
 - c. In areas to be cleared, removing all stumps, roots ½-inch or larger, organic material, and debris to a depth of approximately one foot below existing grade, or one foot below the proposed subgrade elevation, whichever is lower.
 - d. Stockpiling topsoil material on site in areas designated by the OWNER, OWNER'S ENGINEER or Facility Personnel.
2. Grade areas to receive fill to a uniform surface. Scarify surface if directed by the OWNER'S ENGINEER and OWNER.

3. Dry or wet subgrade at the discretion of the OWNER'S ENGINEER and OWNER to establish subgrade with acceptable moisture content.
4. Do not construct structural fill layer until the subgrade has been approved by the OWNER'S ENGINEER and OWNER.

B. Construction

1. Construct project features to the lines and grades shown on the drawings.
2. Place fill material in lifts no greater than nine inches compacted depth.
3. Compact fill material to a minimum percentage of the maximum dry density as determined by a standard Proctor (ASTM D698) as shown in the table below:

Material Type / Use	Compaction Requirement	Moisture Content
Structural Fill / Liner Subgrade	90%	-2% to +4%
Structural Fill / Road Subgrade	98%	-2% to +2%
Structural Fill / Trench Backfill & Stockpile	90%	-2% to +4%
CCR / Liner Subgrade	90%	-4% to +4%
Protective Cover Soil	90%	-2% to +4%
Structural Fill / Embankments	95%	-2% to +4%
Structural Fill / Foundations	95%	-2% to +4%
Structural Fill / All other uses	95%	-2% to +4%
Vegetative Soil / Final Cover	Do not compact	n/a

4. Fill material in place, which does not meet the density requirements, shall be recompacted or removed and reworked to meet density objectives.
5. Do not place or compact fill material during sustained period of temperatures below 32° F.
6. Employ a professional land surveyor licensed in Virginia to conduct a topographic survey of the top of the liner subgrade layer, and prepare a survey drawing showing contours at maximum two-foot intervals.
7. Furnish the OWNER'S ENGINEER and OWNER with three copies of the topographic survey drawing. This drawing shall become part of the record drawings required by this contract.

3.07 Protection and Acceptance

- A. Protect the finished surface from erosion, desiccation, or other damage.
- B. CONTRACTOR shall take steps to protect the installed geosynthetics during placement of the final cover and vegetative support layer soils. CONTRACTOR shall, at a minimum:

1. Prevent vehicular traffic from driving on the geosynthetics until placement of a minimum of 18 inches of final cover soil.
 2. Only approved, low-ground-pressure vehicles shall be allowed to drive on final cover areas with underlying geosynthetics unless adequate measures have been taken to prevent damage to the geosynthetics.
 3. Additional geosynthetics protection methods shall be submitted to the OWNER'S ENGINEER and OWNER for approval.
- C. Develop a contingency plan for responding to construction deficiencies due to inclement weather, defective materials, and construction inconsistent with the Technical Specifications. The plan shall provide a methodology for selecting and implementing corrective action.
- D. Portions of the work damaged due to exposure shall be reworked to meet the Technical Specifications or, at the discretion of the OWNER'S ENGINEER and OWNER, removed and replaced with conforming material at no additional cost to the OWNER.

3.08 Removal Of Shoring And Bracing Materials

- A. Where the CONTRACTOR elects and is permitted not to remove shoring and bracing material, all such material shall be removed to the extent that the top of the material shall be a minimum of 5 feet below the proposed finished grade. No shoring or bracing may remain in place within the limits of the proposed geomembrane liner placement.
- B. Removal of shoring and bracing shall be carried out in a manner such that no structure shall be disturbed or damaged during or after removal. Protection of structures during the removal of shoring and bracing shall be the sole responsibility of the CONTRACTOR, and any disturbance or damage shall be rectified at no expense to the OWNER.

3.09 Quality Assurance

- A. The CQA Consultant shall observe the stripping and stockpiling of existing soils to identify when CCR materials are encountered. The CQA Consultant shall identify the extent of the CCR material and verify the CONTRACTOR does not place unsuitable material into the soil stockpile.
- B. Under the supervision of the OWNER'S ENGINEER and OWNER, a soils technician from a commercial geotechnical testing company approved by the OWNER'S ENGINEER and OWNER shall perform soil tests described herein and in the Construction Quality Assurance (CQA) Plan. Samples shall be collected by field testing personnel at the minimum frequencies presented below.
- C. Test schedule for placement of structural fill:
1. At least one USCS classification shall be performed per 5,000 cubic yards of structural fill placed. The USCS classification shall conform to ASTM D2487 (which includes Grain Size Analysis - ASTM D422 (or D6913) and Atterberg Limits (D4318)).

2. At least one moisture content test shall be performed per 10,000 cubic yards of structural fill placed. The moisture content tests shall conform to ASTM D2216.
 3. At least one moisture-density relationship (Proctor) test for 10,000 cubic yards of structural fill. The moisture density curve test shall conform to ASTM D698.
 4. Additional tests may be required when soil gradation tests indicate that there has been a change in the material being supplied.
 5. Testing of the structural fill will include in-place density and moisture content tests in accordance with ASTM D6938. Frequency: one test per 10,000 square feet per lift.
 6. The horizontal and vertical location of all test locations will be recorded by the CQA Consultant. A drawing will be prepared showing all test locations.
- D. Testing of the trench backfill will include in-place moisture content and density tests in accordance with ASTM D6938. Frequency: One test per 100 linear feet of trench.
- E. The CONTRACTOR shall cooperate with the OWNER'S ENGINEER and the Owner's Representative in obtaining samples for testing and conducting in-situ tests during the construction period. The CONTRACTOR shall provide all necessary labor, equipment, and material to refill sample locations as directed.
- F. If the tests conducted on a particular lift of the placed material do not meet required specifications, the CONTRACTOR shall be responsible for any expenses incurred performing additional tests following re-compaction of the material until passing test results are achieved.

* * * * * END OF SECTION * * * * *

SECTION 310516
COARSE AGGREGATE

PART 1 - GENERAL

1.01 Description Of Work

- A. CONTRACTOR shall furnish all labor, Materials and Equipment, Construction Aids, tools, and appurtenances required to complete the Work of furnishing, placing and compacting the stone as shown, specified or required. CONTRACTOR shall provide a "Competent Person" to implement and supervise all work.
- B. Comply with all Laws and Codes.

1.02 Related Sections

- A. Earthwork – Section 310000
- B. Geotextile – Section 310519.13

PART 2 - PRODUCTS

2.01 Material

- A. The material shall be clean, sound, tough, durable, angular, subangular, subrounded, or round stone, not lumpy, and free from slag, cinders, ashes, rubbish, or other deleterious material. Subangular, angular, subrounded, and round shall be as defined in ASTM D2488 entitled "Standard Practice for Description and Identification of Soils [Visual-Manual Procedure]."
- B. CONTRACTOR shall maintain a uniform gradation of coarse aggregate.
- C. Aggregate shall be stored in designated areas approved by the OWNER. The CONTRACTOR is responsible for maintaining the stone free of contamination, and any stone determined by the OWNER to be contaminated shall not be incorporated into the Work.

D. Coarse Aggregate shall meet the following grading requirements.

1. VDOT No. 57:

<u>Opening of Sieve Size</u>	<u>Percent Passing by Weight</u>
1-1/2 inch	100
1 inch	95-100
1/2 inch	25-60
No. 4	0-10
No. 8	0-5

2. VDOT Graded Aggregate Base:

<u>Opening of Sieve Size</u>	<u>Percent Passing by Weight</u>
1-1/2 inch	95-100
3/4 inch	70-92
3/8 inch	50-70
No. 4	35-55
No. 30	12-25
No. 16	0-8

3. VDOT 21 A Aggregate (for roads):

<u>Opening of Sieve Size</u>	<u>Percent Passing by Weight</u>
2 inch	100
1 inch	90-100
3/8 inch	57.5-76.5
No. 10	31-45
No. 40	17-25
No. 200	8-12

4. VDOT 21 B Aggregate (for roads):

<u>Opening of Sieve Size</u>	<u>Percent Passing by Weight</u>
2 inch	100
1 inch	85-95
3/8 inch	50-69
No. 10	20-36
No. 40	9-19
No. 200	4-7

2.02 Testing

- A. The CONTRACTOR shall submit to the OWNER and CQA Consultant certification that the materials proposed for use as coarse aggregate comply with specification for the proposed application. The certification shall include, but not necessarily be limited to testing provided by the material supplier including one or more of the following tests:
 - 1. Grain Size, ASTM C136
- B. Additional confirmatory testing may be required by the OWNER to confirm compliance with the Contract and these specifications.

PART 3 - EXECUTION

3.01 Placement

- A. A uniform layer of coarse aggregate shall be placed to the lines, depths, and grades as shown on the drawings.
- B. Backfilling of coarse aggregate shall be performed by the CONTRACTOR in a manner such that the material is kept clean and free of foreign materials.
- C. For pipe bedding, the bedding and backfill shall be compacted with the compaction effort acceptable to the Owner. The compaction effort shall be applied to both the bedding and the backfill around the pipes. The method of compaction shall not damage the pipe, geotextile or the geomembrane liner.
- D. Either VDOT 21A or VDOT 21B may be used as aggregate for roads.
- E. The Owner will at any time inspect the stone in the trenches or in stockpile on-site for contamination and, if necessary, reject all or portions of the stone.
- F. The CONTRACTOR shall use extreme care in the placing of the material over geosynthetics. The material shall be placed in a manner to maintain a minimum thickness of eighteen inches between the geosynthetics and the spreading equipment. All coarse aggregate, placed within the limits of the geosynthetics, shall be placed by low pressure equipment. Equipment with ground pressure less than 5 psi may travel on a minimum 18-inch thick coarse aggregate layer. Equipment with a ground pressure equal to or greater than 5 psi must travel on a minimum 36-inch thick coarse aggregate layer.

* * * * * END OF SECTION * * * * *

SECTION 310519.13

GEOTEXTILE

PART 1 - GENERAL

1.01 Description Of Work

- A. The CONTRACTOR shall furnish all labor, Materials and Equipment, Construction Aids, tools and appurtenances required to complete the work of furnishing, and placing geotextile, complete with appurtenances, as shown, specified or required.
- B. Comply with all Laws and Codes.

1.02 Related Sections

- A. Earthwork – Section 310000
- A. Coarse Aggregate – Section 310519.13
- B. HDPE Geomembrane – Section 310519.16

1.03 Submittals

- A. The CONTRACTOR shall furnish a mill certificate from the company manufacturing the woven and non-woven geotextile attesting that the geotextile meets the chemical, physical, and manufacturing requirements specified. Geotextiles shall be rejected by the OWNER and replaced by the CONTRACTOR if they are found to have defects, rips, holes, flaws, deterioration or other damage.
- B. The CONTRACTOR shall submit shop drawings to the Owner showing proposed construction methods: geosynthetics panel arrangements; and tie-in details between geosynthetics, drainage structures, fill materials, and the like.

1.04 Product Handling

- A. The CONTRACTOR shall protect the Work described in this Section before, during, and after installation, and shall protect the installed Work covered by other Sections.
- B. The CONTRACTOR shall, during all periods of shipment and storage, protect the geotextile from direct sunlight, ultraviolet light, temperatures greater than 120 degrees F, mud, dirt, dust, debris, and other deleterious sources. Geotextiles shall be maintained, wrapped in a heavy-duty protective covering until it is installed.
- C. If the CQA Consultant and Owner determines material is damaged or has excessive sunlight exposure, the CONTRACTOR shall immediately make all repairs and replacements, at no additional cost to the OWNER.

1.05 Definitions

- A. On the drawings and in the Specifications, the word geotextile is used and refers to either a woven or non-woven geotextile as described in Section 2.01.

1.06 Conformance Testing Of Geotextile

- A. Filter geotextiles will be tested prior to shipment to ensure that the properties of the finished product are in accordance with the construction specifications. Geotextile samples will have test results for the properties and to the requirements given in Section 2.01 or Section 2.02. Each roll of geotextile will have the product identification, roll number, lot number, date of manufacturer, and manufacturer name clearly marked.
- B. Prior to or upon delivery of the geotextile to the Project Site, the OWNER shall obtain certifications for the materials.
- C. Upon delivery of woven geotextile to the Project Site, the Owner and CQA Consultant shall obtain representative samples of the furnished product for conformance testing. The required material properties, test methods, values, and units are presented in Section 2.02. CQA conformance testing is not required for woven geotextiles.

PART 2 - MATERIALS

2.01 Woven Geotextile

- A. Woven geotextiles used shall be manufactured by Mirafi, Amoco, Exxon, Nicolon, Hoechst, or other approved manufacturers. Woven geotextiles shall meet the requirements of AASHTO M288 Survivability Class 2 or better.
- B. Woven geotextile shall meet the following MARV minimum properties:

Property	Test Method	Value
Polymer Composition	-	95% polypropylene or polyester by weight
Grab Tensile Strength	ASTM D4632	200 lbs
Grab Tensile Elongation	ASTM D4632	10% - 15%
Puncture Strength	ASTM D6241	700 lbs
Apparent Opening Size	ASTM D4751	40 sieve (0.425 mm)

- C. To keep the number of seams to a minimum, the geotextile shall be provided in rolls not less than 12 feet wide.

2.02 Nonwoven Geotextile

- A. Nonwoven geotextile shall meet the requirements of AASHTO M288 Survivability Class 2 and be suitable for fines in excess of 50% in the surrounding material.
- B. Non-woven geotextile shall meet the following MARV minimum properties:

Property	Test Method	Value	Manufacturer's QC Testing Frequency	QA Testing Frequency
Polymer Composition	-	95% polypropylene or polyester by weight	Certified by Manufacturer	N/A
Grab Tensile Strength	ASTM D4632	160 lbs (MD) ¹	1 test per 50,000 sf	1 test per 100,000 sf
Grab Tensile Elongation	ASTM D4632	50 % (MD) ¹	1 test per 50,000 sf	1 test per 100,000 sf
Trapezoidal Tear Strength	ASTM D4533	60 lb	1 test per 50,000 sf	1 test per 100,000 sf
Puncture Strength	ASTM D6241	400 lbs	1 test per 50,000 sf	1 test per 100,000 sf
Apparent Opening Size	ASTM D4751	70 sieve	1 per production lot	1 test per 200,000 sf
Permittivity	ASTM D4491	1.0 sec ⁻¹	1 per production lot	1 test per 200,000 sf
UV Resistance	ASTM D4355	70 %	Certified by Manufacturer	N/A

1. Machine Direction

PART 3 - EXECUTION

3.01 Site Preparation

- A. Site subgrade preparation shall conform to the requirements of this Section, and Section 310000 - Earthwork.
- B. The surface to receive geotextile shall be cleared of sharp objects, boulders, stumps, or any materials that may contribute to fabric punctures, shearing, rupturing, or tearing to the satisfaction of the OWNER and OWNER'S ENGINEER.
- C. The base surface or surface of embankments shall be graded as smooth as possible and compacted with a smooth – drum roller. The subgrade shall be inspected for unstable areas or soft spots, before the geotextile is placed and additional fill shall be placed and compacted to eliminate those unstable areas.

3.02 Installation

- A. The geotextile shall be placed in the manner and at the locations shown. Geotextile shall be laid smooth and free of tension, stress, folds, wrinkles, or creases.
- B. Woven geotextile will be overlapped a minimum of 2 feet, with the upgradient rolled lapped over the downgradient roll, prior to placing stone.
- C. All filter geotextile seams shall be continuously sewn or by means approved by the OWNER and the OWNER'S ENGINEER. Spot sewing is not allowed. Filter geotextiles will be overlapped a minimum of 6 inches prior to seaming.

- D. No vehicles shall be permitted on the geomembrane or non-woven geotextile prior to placement of at least 18 inches of cover material. Equipment with ground pressure less than 5 psi may travel on a minimum 18-inch layer. Equipment with ground pressure equal to or greater than 5 psi must travel on a minimum 36-inch thick layer.
- E. Stone or drainage collection material shall be spread in the direction of the geotextile overlap (i.e., upgradient to downgradient).
- F. If geotextile is damaged during any step of installation, a piece of geotextile material shall be cut and placed over the damaged area and overlap the undamaged material a minimum of 3 feet in each direction.
- G. The geotextile shall be placed on side slopes as shown on the contract drawings. If necessary, the geotextile shall be positioned by hand after being unrolled to minimize wrinkles. The geotextile shall not be placed in the horizontal direction (i.e. across the slope) on slopes steeper than 10 (horizontal): 1 (vertical), except as part of a patch.

3.03 Protection

- A. After installation, the geotextile should be visually inspected to assure that no objects are present that could potentially harm the geotextile.
- B. Any geotextile damaged during its installation or during placement of cover material, as deemed by the Owner, shall be replaced by the CONTRACTOR at no additional cost to the OWNER.
- C. The Work shall be scheduled so that the covering of the geotextile with the material to be placed over it is accomplished within 30 days after placement of the geotextile. Failure to comply with this requirement shall require replacement of an additional geotextile at no additional cost to the Owner.
- D. When spot-repairing geotextile with patches, a 3-foot lystered overlap will be used or by a means approved by the OWNER.

* * * * * END OF SECTION * * * * *

SECTION 310519.16a

HDPE GEOMEMBRANE LINER

PART 1 - GENERAL

1.01 Work Included

- A. The Work set forth in this section includes the specifications and guidelines for the manufacture, installation, and testing of High Density Polyethylene (HDPE) geomembrane.

1.02 Related Work

- A. Carefully examine all of the Contract Documents for requirements that affect the work of this section.
- B. Other specification sections that contain requirements relating to this work include, but are not limited to, the following:
 - 1. Earthwork – Section 310000

1.03 References

- A. Quality Assurance/Quality Control Plan
- B. Latest Version of American Society for Testing and Materials (ASTM) standards:
 - 1. D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
 - 2. D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
 - 3. D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
 - 4. D 1505 Test Method for Density of Plastics by Density-Gradient Technique
 - 5. D 3895 Test Method for Oxidative Inductive Time of Polyolefins by Thermal Analysis
 - 6. D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
 - 7. D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
 - 8. D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

9. D 5397 Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix
 10. D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
 11. D 5617 Test Method for Multi-Axial Tension Test for Geosynthetics
 12. D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
 13. D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
 14. D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes
 15. D 6693 Test Method for Determining Tensile Properties of Non-reinforced Polyethylene and Non-reinforced Flexible Polypropylene Geomembranes
- C. Geosynthetic Research Institute (GRI) Standard Specifications and Test Methods:
1. GRI GM-9 Cold Weather Seaming of Geomembranes
 2. GRI GM-11 Accelerated Weathering of Geomembranes Using a Fluorescent UVA-Condensation Exposure Device
 3. GRI GM-12 Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gauge
 4. GRI GM-13 Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
 5. GRI GM-19 Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.03 Submittals

- A. Prior to Material Delivery
1. No material shall be delivered to the Project Site until the material and performance documentation and certifications have been received and reviewed by the OWNER or CQA Consultant. Documentation shall include quality control (QC) test results on the manufactured geomembrane sheet and certification stating the geomembrane roll numbers, base resin type, and lot from which it was produced.
 2. The Manufacturer shall supply the following product data to the OWNER'S ENGINEER, OWNER, and CQA Consultant:
 - a. Resin data including the following:

- i. Certification stating that the resin meets the requirements of this Technical Specification,
 - ii. Certification stating all resin is from the same Manufacturer, and
 - iii. A copy of the QC certificates issued by the geomembrane Manufacturer and resin supplier.
 - b. Geomembrane sheet data including the following:
 - i. Certification that material reworked from manufacturing process will not exceed 10 percent by weight of material in accordance with GRI GM-17.
 - ii. A copy of the QC certificates issued by the geomembrane Manufacturer.
 - c. Certification that extrudate resins and/or rod are from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane material.
- B. Prior to Material Installation (minimum of two weeks)
 - 1. Installer shall supply shop drawings that include, at a minimum, a panel diagram with details (i.e. pipe boots and seaming process). The panel diagram shall indicate the proposed geomembrane panel layout for approval. This approval will be for concept only; the actual panel layout will be determined by site conditions. This diagram should be in sufficient detail to provide an accurate representation of the field seaming that will be completed. Any revisions to the panel diagram shall be approved by the OWNER or CQA Consultant prior to further installation operations.
 - 2. The proposed layout of the panels shall be set and approved, ensuring efficiency of material, minimization of field seams, and proper placement of field seams. Field seams should be placed where normally applied stress will be minimal. All seams and slopes steeper than 15 percent shall be completed parallel to the line of maximum slope.
- C. Installation: Submit as installation proceeds.
 - 1. Quality control documentation recorded during installation.
 - 2. Subgrade surface acceptance certificates signed by LINER INSTALLER for each area that will be covered directly by geomembrane.
 - 3. Deployment of geomembrane will be considered acceptance of subgrade if certificate is not submitted.
 - 4. Material and Installation Warranty from manufacturer.

1.04 Prequalifications

A. Manufacturer

1. Manufacturer shall be approved by OWNER in writing and have minimum 5 yrs continuous experience in manufacture of HDPE geomembrane or experience totaling 10,000,000 sq ft of manufactured HDPE geomembrane for minimum of 10 completed facilities.

B. Fabricator (if applicable)

1. Fabricator shall be approved by OWNER in writing and have minimum 5 yrs continuous experience in fabrication of HDPE geomembrane or experience totaling 2,000,000 sq ft of fabricated HDPE geomembrane for minimum of 10 completed facilities.

C. Installer

1. Installer shall be approved by OWNER in writing and have a minimum of 5 yrs continuous experience in installation of HDPE or LLDPE geomembrane or experience totaling 2,000,000 sq ft of installed HDPE or LLDPE geomembrane for minimum of 10 completed facilities.
2. Personnel performing seaming operations shall be qualified by experience or successfully passing seaming tests. Minimum of one seamer shall have experience seaming minimum 2,000,000 sq ft of HDPE or LLDPE geomembrane using the same type of seaming apparatus in use at site. Most experienced seamer, "master seamer," shall provide direct supervision, as required, over less experienced seamers.

1.05 Quality Assurance Program

- A. Manufacturer, fabricator, and installer shall participate in and conform to the items and requirements of quality assurance program as outlined in the Contract, including this Specification and the Quality Assurance Plan.
- B. The OWNER may engage and pay for the services of a CQA Consultant and testing laboratory to monitor the geomembrane installation and complete conformance testing.

1.06 Material Labeling, Delivery, Storage And Handling

A. Packing and Shipping.

1. Manufacturer shall identify each roll delivered to site with the following:
 - a. Manufacturer's name.
 - b. Product Identification.
 - c. Thickness.

- d. Roll number.
 - e. Roll dimensions.
 2. Protect geomembrane from excessive heat, cold, puncture, cutting, or other damaging or deleterious conditions during loading, transport, and unloading at site.
- B. Acceptance at Project Site.
 1. Conduct surface observations of each roll for defects and damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected.
 2. Defected or damaged rolls or portions of rolls will be rejected and shall be removed from the Project Site and replaced with new rolls.
 3. Rolls or portions of rolls without proper identification or labeling will be rejected and shall be removed from the Project Site.
- C. Storage and Protection.
 1. OWNER will provide on-site storage area for geomembrane rolls from time of delivery until deployment.
 2. INSTALLER shall protect geomembrane from dirt, water, and other sources of damage.
 3. Preserve integrity and readability of geomembrane roll labels.
 4. Rolls which do not have proper identification at delivery will not be accepted.

1.07 Warranty

- A. The material shall be warranted on a pro-rata basis against Manufacturer's defects for a period of ten years from the date of geomembrane completion.
- B. The installation shall be warranted against defects in workmanship for a period of two years from the date of geomembrane completion.

PART 2 - PRODUCTS

2.01 Geomembrane

- A. Polyethylene Resin
 1. The resin shall be virgin material with no more than 10% rework. If rework is used, it must be the same formulation of the parent material.
 2. No post-consumer resin of any type shall be added to the formulation.

B. Textured High Density Polyethylene (HDPE) Geomembrane Properties:

Table 2: Minimum Values for Textured HDPE Geomembranes

Testing Properties	Testing Method	40 mil HDPE Value
Thickness (min ave.) <ul style="list-style-type: none"> • Lowest individual for 8 of 10 values • Lowest individual for any value 	ASTM D 5994	38 mil 36 mil 34 mil
Density g/cc	ASTM D1505 or ASTM D792	0.940 mil
Asperity Height (min ave.) (1) (2)	GM-12	16 mil
Tensile Properties (min. ave.) (3) <ul style="list-style-type: none"> Break strength – lb/in Break elongation - % 	ASTM D6693 Type IV	60 100
Tear Resistance – lb (min. ave.)	ASTM D1004	28
Puncture Resistance – lb (min. ave.)	ASTM D4833	60
Stress Crack Resistance (11)	ASTM D5397	500 hr
Carbon Black Content - %	ASTM D1603 (4)	2.0 to 3.0
Carbon Black Dispersion	ASTM D 5596	Note (5)
Oxidative Induction Time (OIT) (min ave.) (6) <ul style="list-style-type: none"> Standard OIT High Pressure OIT 	ASTM D3895 ASTM D5885	100 min 400 min
Oven Aging at 85°C (7) <ul style="list-style-type: none"> Std. OIT (min. ave.), % retained after 90 days High Pressure OIT (min. ave.), % retained after 90 days 	ASTM D5885 ASTM D5721 ASTM D3895	55 80
UV Resistance (8) <ul style="list-style-type: none"> High Pressure OIT (min ave.) % retained after 1600 hrs 	ASTM D5885	50

1. Of 10 readings, 8 out of 10 must be ≥ 14 mils, and lowest individual reading must be ≥ 12 mils
2. Alternate the measurement side for double sided textured sheet.
3. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
 - a. Break elongation is calculated using a gauge length of 2.0 in. at 2.0 in/min.
4. Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
 - a. 9 in Categories 1 or 2 and 1 in Category 3
6. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane

7. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
 8. The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
 9. The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheet made from the same formulation as being used for the textured sheet materials.
- C. Geomembrane shall be manufactured from new polyethylene resin, except as noted below.
1. Use of geomembrane recycled during manufacturing process shall be permitted with written approval from OWNER and if recycled geomembrane does not exceed 2% by weight.
 2. Geomembrane manufactured from non-complying resin shall be rejected.
- D. Geomembrane Characteristics.
1. Contain maximum of 1% by weight of additives, fillers, or extenders (not including carbon black).
 2. Contain between 2% and 3% by weight of carbon black for ultraviolet light resistance.
 3. No pinholes, bubbles or other surface features that compromise geomembrane integrity are allowed. Geomembrane shall be free of blisters, nondispersed raw materials, or other signs of contamination resulting from the manufacturing process. Geomembrane rolls or portions of rolls with these defects shall be rejected.
- E. Geomembrane pre-construction QA samples shall be taken by the CQA Consultant from preshipped material at the factory or from shipped material on site at the frequency provided in Table 2. Samples shall be shipped to the testing laboratory for conformance testing of the properties listed in Table 2 for QA testing.
- F. The extrudate rod and/or bead shall be made from same type of resin as the geomembrane. Additives shall be thoroughly dispersed, and the material shall be free of contamination by moisture or foreign matter.

2.02 Seaming And Testing Equipment

- A. Welding.
1. Maintain on-site a minimum of 2 spare operable seaming apparatus, unless otherwise agreed upon at the pre-construction meeting.
 2. Seaming equipment shall not damage geomembrane.

3. Use extrusion welding apparatus equipped with gauges giving temperature of extrudate at nozzle of apparatus, or utilize hand-held gauges to measure extrudate temperatures.
4. Use fusion-welding apparatus that are self-propelled devices equipped with following:
 - a. Gauge indicating temperature of heating element.
 - b. Gauge indicating the speed of travel
5. Place electric generator on smooth base such that no damage occurs to geomembrane.

B. Vacuum Testing Equipment:

1. Vacuum box assembly consisting of: rigid housing, transparent viewing window, soft neoprene gasket attached to bottom of housing, porthole or valve assembly, and vacuum gauge.
2. Pump assembly equipped with pressure controller and pipe connections.
3. Pressure/vacuum rubber hose with fittings and connections.
4. Soapy solution to wet test area.
5. Means of applying soapy solution.

C. Air Pressure Testing Equipment:

1. Air pump (manual or motor driven), equipped with a pressure gauge, capable of generating, sustaining, and measuring pressure between 20 and 35 psi, and mounted on cushion to protect geomembrane.
2. Rubber hose with fittings and connections.
3. Sharp hollow needle, or other approved pressure feed device.
4. Air pressure monitoring device.

D. Tensiometer Testing Equipment:

1. Tensiometer shall be capable of maintaining constant jaw separation rate of 2 in. per minute, and shall be calibrated, with certificate of calibration less than 1 yr old kept with tensiometer.

2.03 Source Quality Control

- A. Tests, Inspections shall be performed by geomembrane manufacturer as follows:

1. Test geomembranes to demonstrate that resin meets this Specification.
2. Continuously monitor geomembrane during manufacturing process for inclusions, bubbles, or other defects. Geomembranes, which exhibit defects, shall not be acceptable for installation.
3. Monitor thickness continuously during manufacturing process.
4. Tests shall be conducted for following properties in accordance with the test methods specified in the following table. Samples not complying with Specifications shall result in rejection of rolls. At the geomembrane manufacturer's discretion and expense, additional testing of individual rolls may be performed to identify and reject non-complying rolls and to approve individual rolls.

Testing Properties	Testing Method	Manufacturer QC Testing Frequency
Thickness mils	ASTM D 5994	1 per Roll;
Density g/cc	ASTM D1505 or ASTM D792	1 per 500,000 sf
Asperity Height (1) (2)	GM-12	Every 2 nd roll
Tensile Properties (3)	ASTM D6693 Type IV	1 per 50,000 sf
Tear Resistance – lb	ASTM D1004	1 per 100,000 sf
Puncture Resistance – lb	ASTM D4833	1 per 100,000 sf
Stress Crack Resistance (9)	ASTM D5397	per GRI GM10
Carbon Black Content - %	ASTM D1603 (4)	1 per 50,000 sf
Carbon Black Dispersion (5)	ASTM D 5596	1 per 100,000 sf
Oxidative Induction Time (OIT) (6) <ul style="list-style-type: none"> • Standard OIT, or • High Pressure OIT 	ASTM D3895 ASTM D5885	(9)
Oven Aging at 85°C (7) <ul style="list-style-type: none"> • Std. OIT, % retained after 90 days or <ul style="list-style-type: none"> • High Pressure OIT, % retained after 90 days 	ASTM D5721 ASTM D3895 ASTM D5885	(9)
UV Resistance (8) <ul style="list-style-type: none"> • Std. OIT, or • High Pressure OIT % retained after 1600 hrs 	ASTM D3895 ASTM D5885	(9)

1. Of 10 readings, 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils

2. Alternate the measurement side for double sided textured sheet.
3. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
 - a. Break elongation is calculated using a gauge length of 2.0 in. at 2.0 in/min.
4. Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
 - a. 9 in Categories 1 or 2 and 1 in Category 3
5. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
6. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
7. The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
8. Manufacturer may provide a certification letter

PART 3 - EXECUTION

3.01 Quality Assurance Sampling

- A. CONTRACTOR or INSTALLER shall make rolls available and assist GEOSYNTHETIC CONSTRUCTION QUALITY ASSURANCE CONSULTANT (CQAC) in obtaining material inventory and material samples. Samples shall be tested in accordance with the test methods specified in the following table:

Testing Properties	Testing Method	Conformance QA Testing Frequency
Thickness	ASTM D 5994	1 per 200,000 sf
Density g/cc	ASTM D1505 or ASTM D792	1 per 200,000 sf
Asperity Height (1) (2)	GM-12	1 per 200,000 sf
Tensile Properties (3)	ASTM D6693 Type IV	1 per 200,000 sf
Tear Resistance – lb	ASTM D1004	1 per 200,000 sf
Puncture Resistance – lb	ASTM D4833	1 per 200,000 sf
Carbon Black Content - %	ASTM D1603 (4)	1 per 200,000 sf
Carbon Black Dispersion (5)	ASTM D 5596	1 per 200,000 sf

1. Of 10 readings, 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils
2. Alternate the measurement side for double sided textured sheet.
3. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
 - a. Break elongation is calculated using a gauge length of 2.0 in at 2.0 in/min.
4. Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:

- a. 9 in Categories 1 or 2 and 1 in Category 3
- B. Rolls represented by quality assurance testing shall be rejected if test failure occurs. INSTALLER may at their expense request additional testing to validate individual rolls. Rolls bracketed by passing tests will be allowed to be deployed and seamed.

3.02 Preparation

A. Surface Preparation:

1. CONTRACTOR is responsible for preparing supporting surface for geomembrane placement.
2. After prepared surface has been accepted in accordance with the Quality Assurance Plan, report to OWNER any change in supporting surface condition that may require repair work. Maintain prepared surface.
3. Do not place geomembrane onto an area that has become softened by precipitation or cracked due to desiccation. Observe and report surface condition daily to evaluate degree of softening and desiccation cracking.
4. Repair damage to prepared surface caused by installation activities at INSTALLER'S expense.

3.03 Installation

A. Panel Nomenclature:

1. Field panel is defined as a roll or portion of roll cut and seamed in field, excluding patches and cap strips.
2. Identify each field panel with identification code (number or letter-number) consistent with INSTALLER'S layout plan. This identification code shall be agreed upon by OWNER, INSTALLER, and GEOSYNTHETIC CQAC.
3. Writing on liner with colored markers shall be as agreed upon in the Pre-Construction Meeting. Only authorized personnel shall be permitted to write on liner.

B. Protection:

1. Do not use equipment that damages geomembrane.
2. Ensure prepared surface underlying geomembrane has not deteriorated since previous acceptance, and remains acceptable immediately prior to geomembrane deployment.
3. Do not permit personnel to smoke or wear shoes that can damage geomembrane while working on geomembrane. Personnel shall not bring glass bottles on geomembrane.

4. Unroll panels in manner that does not cause excessive scratches or crimps in geomembrane and does not damage supporting soil.
5. Place panels in manner that minimizes wrinkles (especially differential wrinkles between adjacent panels).
6. Prevent wind uplift by providing adequate temporary loading and/or anchoring (e.g., sandbags) that shall not damage geomembrane. In case of high winds, continuous loading is recommended along panel edges.
7. Protect geomembrane in areas where excessive traffic is expected with geotextiles, extra geomembrane, or other suitable materials.

C. Field Panel Deployment:

1. Install field panels at locations indicated on INSTALLER'S layout plan.
2. Replace seriously damaged (torn, twisted, or crimped) field panels, or portions thereof, at no cost to OWNER. Repair less serious damage as specified herein. GEOSYNTHETIC CQAC shall determine if material shall be repaired or replaced.
3. Remove damaged panels or portions of damaged panels that have been rejected from work area.
4. Do not proceed with deployment at ambient temperature below 32°F or above 104°F unless otherwise authorized, in writing, by OWNER.
5. Do not deploy during precipitation, in presence of excessive moisture, (fog, dew), in areas of ponded water or in presence of excessive winds.
6. Do not undertake deployment in weather conditions that will preclude material seaming on same day as deployment.
7. Do not deploy more geomembrane field panels in one day than can be seamed during that day.

D. Seam Layout:

1. When possible, orient seams parallel to line of maximum slope, i.e., oriented along, not across, slope.
2. No horizontal seam shall be less than 5 ft from the top of or toe of slope.
3. In general, maximize lengths of field panels and minimize number of field seams.

4. Align geomembrane panels to have nominal overlap of 3 in. for extrusion welding and 4 to 6 in. for fusion welding. Final overlap shall be sufficient to allow peel tests to be performed on the seam.

E. Temporary Bonding:

1. Hot air device (Liester) may be used to temporarily bond geomembrane panels to be extrusion welded.
2. Do not damage geomembrane when temporarily bonding adjacent panels. Apply minimal amount of heat to lightly tack geomembrane panels together. Control temperature of hot air at nozzle of any temporary welding apparatus to prevent damage to geomembrane.
3. Do not use solvent or adhesive.

F. Seaming Methods:

1. Approved processes for field seaming are extrusion fillet welding and fusion welding. Proposed alternate processes shall be documented and submitted to OWNER for approval. Alternate procedures shall be used only after being approved in writing by OWNER.
2. Seams shall meet following requirements:

MINIMUM POLYETHYLENE SEAM PROPERTIES (per GRI GM-19)

Property	Method	40-mil HDPE
Peel Strength (fusion)	ASTM D6392	60 ppi
Peel Strength (extrusion)	ASTM D6392	52 ppi
Shear Strength (fusion and extrusion)	ASTM D6392	80 ppi

1. The strength of four of five specimens shall meet or exceed the value shown in this table. The fifth must meet or exceed 80% of the given value in order to be considered a passing test.
2. Unacceptable break codes are:
 - a. Fusion: AD and AD-Brk>25%
 - b. Extrusion: AD1, AD2, AD-WLD (unless strength is achieved)
3. Use fusion welding as primary method of seaming adjacent field panels.
 - a. Cross seam tees, associated with fusion welding or extrusion welding, shall be patched to a minimum distance of 6-in. on each side of tee.
 - b. Place welder on protective pad to prevent geomembrane damage between seaming.

- c. When subgrade conditions dictate, use movable protective layer (e.g. extra piece of geomembrane) directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between sheets and prevent debris from collecting around pressure rollers.
4. Use extrusion fillet welding as secondary method for seaming between adjacent panels and as primary method of welding for detail and repair work.
- a. Purge heat-degraded extrudate from barrel of extruder under following conditions:
 - i. Prior to beginning seam.
 - ii. Whenever extruder has been inactive.
 - b. Place a smooth insulating plate or fabric beneath the hot welding apparatus after usage.
 - c. Use clean and dry welding rod or extrudate pellets.
 - d. Complete grinding process without damaging geomembrane and within 1 hr of seaming operation.
 - e. Minimize exposed grinding marks adjacent to extrusion weld. Do not allow exposed grinding marks to extend more than 1/4 in. outside finished seam area and grind perpendicular to seam.

G. Seaming Procedures:

- 1. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. The Installer shall demonstrate that acceptable seaming can be achieved by completing acceptable trial welds.
- 2. General Seaming Procedures: (Ambient temperature between 32°F and 104°F).
 - a. Do not field seam without master seamer being present.
 - b. Dry conditions - no precipitation or other excessive moisture, such as fog or dew.
 - c. No excessive winds.
 - d. If required, provide firm substrate by using extra piece of geomembrane, or similar hard surface directly under seam overlap to achieve proper support for seaming apparatus.
 - e. Align seams with fewest possible number of wrinkles and fishmouths.

- f. Extend seams to outside edge of panels placed in anchor trench.
 - g. Prior to seaming, ensure that seam area is clean and free of moisture, dust, dirt, debris, or foreign material.
 - h. Fishmouths or wrinkles at seam overlaps shall be cut along ridge of wrinkle in order to achieve flat overlap. Cut fishmouths or wrinkles shall be seamed and any portion where overlap is inadequate shall be patched with an oval or round patch of same geomembrane extending minimum of 6-in. beyond cut in each direction.
3. Cold Weather Seaming Procedures (ambient temperature is below 32° F).
- a. GEOSYNTHETIC CQAC shall determine geomembrane surface temperatures at intervals of at least once per 100 ft of seam length to determine if preheating is required. For extrusion welding, preheating shall be required if the surface temperature of the geomembrane is below 32° F.
 - b. Preheating may be waived by OWNER based on recommendation from GEOSYNTHETIC CQAC, if demonstrated to GEOSYNTHETIC CQAC'S satisfaction that welds of equivalent quality may be obtained without preheating.
 - c. If preheating is required, GEOSYNTHETIC CQAC shall observe areas of geomembrane that have been preheated by hot air device prior to seaming, to ensure they have not been subjected to excessive melting.
 - d. GEOSYNTHETIC CQAC shall confirm that surface temperatures are not below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.
 - e. Preheating devices used shall be pre-approved by OWNER prior to use.
 - f. Additional destructive seam tests shall be taken at interval between 500 ft and 250 ft of seam length, at GEOSYNTHETIC CQAC'S discretion.
 - g. Sheet grinding may be performed before preheating, if applicable.
 - h. Trial seaming shall be conducted under same ambient temperature and preheating conditions as actual seams. New trial seams shall be conducted if ambient temperature drops by more than 10° F from initial trial seam test conditions. New trial seams shall be conducted upon completion of seams in progress during temperature drop.
3. Warm Weather Procedures (ambient temperature is above 104° F).

- a. No seaming of geomembrane is permitted unless it is demonstrated to GEOSYNTHETIC CQAC that the geomembrane seam quality will not be compromised.
- b. Trial seaming shall be conducted under the same ambient temperature conditions as actual seams. New trial seams shall be conducted if the ambient temperature rises by more than 5° F from initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during temperature rise.
- c. At the option of the GEOSYNTHETIC CQAC, additional destructive seam tests may be required for suspect areas.

H. Repair Procedures:

1. Repair portions of geomembrane exhibiting flaws, or failing destructive or nondestructive tests.
2. The final decision as to repair procedure shall be agreed upon between OWNER, INSTALLER, and GEOSYNTHETIC CQAC.
3. Acceptable repair procedures include the following:
 - a. Patching: Piece of same geomembrane material extrusion welded into place. Use to repair large holes, tears, nondispersed raw materials, and contamination by foreign matter. All panel intersections shall be patched.
 - b. Spot welding or seaming: Bead of molten extrudate placed on flaw. Use to repair small tears, pinholes, or other minor, localized flaws.
 - c. Capping: Strip of same geomembrane material extrusion welded into place over inadequate seam. Use to repair large lengths of failed seams.
 - d. Removal and replacement: Remove bad seam and replace with strip of same geomembrane material welded into place. Use to repair large lengths of failed seams.
 - e. Extrusion welding flap: Repairs of this type shall not be used unless approved by GEOSYNTHETIC CQAC and shall not exceed 100 ft in length.
4. For each repair method:
 - a. Ensure surfaces are clean, dry, and prepared in accordance with specified seaming process.
 - b. Ensure seaming equipment used in repairing procedures meet requirements of this Specification.

- c. Extend patches or caps at least 6 in. beyond edge of defect. Round corners of patches with radius of approximately 6 in.
5. Do not place overlying layers over locations which have been repaired until appropriate acceptable nondestructive and destructive (laboratory) test results are obtained.

J. Anchor Trench:

1. EARTHWORK CONTRACTOR shall excavate anchor trenches, unless otherwise specified, to lines and grades shown on design construction drawings prior to geomembrane placement. Anchor trench shall be drained to prevent ponding or softening of adjacent soils while trench is open.
2. Slightly rounded corners shall be provided in the anchor trench to avoid sharp bends in geomembrane.
3. If the anchor trench is excavated in clay material susceptible to desiccation, the amount of trench open at any time should be minimized.
4. Remove construction-related debris from anchor trench.
5. Earthwork Contractor shall backfill and compact anchor trench as soon as practical after geomembrane installation is completed. Take care when backfilling trenches to prevent damage to geosynthetics.

3.04 Field Quality Control

A. Visual Inspection:

1. GEOSYNTHETIC CQAC will examine seam and non-seam areas of geomembrane for identification of defects, holes, blisters, nondispersed raw materials, and any sign of contamination by foreign matter.
2. Clean and wash geomembrane surface if GEOSYNTHETIC CQAC determines that amount of dust or mud inhibits examination.
3. Do not seam any geomembrane panels that have not been examined for flaws by GEOSYNTHETIC CQAC.
4. Nondestructively test seams and any non-seam areas identified by GEOSYNTHETIC CQAC.

B. Trial Seams:

1. Make trial seams on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming.

2. Make trial seams at beginning of each seaming period, following restart of welding equipment, upon change of seamers, and at least once every 4 to 6 hours, for each production seaming apparatus used that day.
3. Make trial seams under same conditions as actual seams.
4. Make trial seams only under observation of GEOSYNTHETIC CQAC.
5. Seam overlap shall be as indicated for finished seam.
6. Make trial seam sample shall be at least 5 ft long by 1 ft wide (after seaming) with seam centered lengthwise.
7. Cut 9 specimens from sample with 1 in. wide die. These specimen locations shall be selected randomly along trial seam sample by GEOSYNTHETIC CQAC. Test 3 specimens in inside peel, 3 specimens in outside peel, and 3 specimens in shear using field tensiometer. Samples shall fail in sheet or exceed the specified peel and shear criteria stated in this Specification.
8. If specimen fails, entire trial seam operation shall be repeated. If additional specimen fails, do not use seaming apparatus and seamer until deficiencies are corrected and two (2) consecutive successful trial welds are achieved.
9. The remainder of the successful trial seam is to be retained by GEOSYNTHETIC CQAC for possible laboratory destructive seam testing until project completion.

C. Nondestructive Seam Testing:

1. General:
 - a. Purpose of nondestructive tests is to check continuity of seams. It will not provide quantitative information on seam strength.
 - b. Nondestructively test field seams over their full length using vacuum test for extrusion seams, air pressure for double-fusion seams, or other OWNER approved method. Document results.
 - c. Perform nondestructive testing as seaming work progresses.
2. Vacuum Testing for extrusion seam:
 - a. Energize vacuum pump and reduce tank pressure to approximately 3 psi gauge pressure.
 - b. Wet strip of geomembrane approximately 12 in. by 48 in. with soapy solution.
 - c. Place box over wetted area.
 - d. Close bleed valve and open vacuum valve.

- e. Ensure that leak-tight seal is created.
- f. For minimum of 10 sec, apply vacuum and examine geomembrane through viewing window for presence of soap bubbles.
- g. If no bubbles appear within 10 sec, close vacuum valve and open bleed valve, move box over to next adjoining area with minimum 3 in. overlap and repeat process.
- h. Mark and repair areas where soap bubbles appear.

3. Air Pressure Testing for double-fusion seam:

- a. Seal both ends of seam to be tested.
- b. Insert needle or other approved pressure feed device into air channel created by fusion weld.
- c. Insert protective cushion between air pump and geomembrane.
- d. Pressurize air channel to 30 psi. Close valve and allow pressure to stabilize for approximately 2 minutes.
- e. Observe air pressure 5 min after initial 2-min stabilization period ends. If pressure loss exceeds 4 psi or pressure does not stabilize, locate faulty area and repair.
- f. Cut opposite end of tested seam area once testing is completed to verify continuity of air channel. If air does not escape, locate blockage and retest unpressurized area. Repair cut end of air channel.
- g. Remove needle or other approved pressure feed device and repair hole in geomembrane.

4. Inaccessible Seams:

- a. Cap-strip seams that cannot be nondestructively tested.
- b. Cap-strip material shall be composed of same type and thickness geomembrane as geomembrane to be capped.
- c. Examine cap-stripping operations with GEOSYNTHETIC CQAC for uniformity and completeness. Document observations.

D. Destructive Seam Testing:

1. General:

- a. Purpose of destructive seam testing to evaluate seam strength.

- b. Perform destructive seam test as seaming progresses.
 - c. The destructive seam sample shall fail if the grips of testing machine cannot be closed on sample test flap (available flap is 1/2 in. long or less) due to excessive temporary welding.
2. Location and frequency:
- a. Test at minimum frequency of one test location per 500 ft of welding length performed by each welding machine.
 - b. Test locations shall be determined during seaming, at GEOSYNTHETIC CQAC'S discretion.
 - c. INSTALLER will not be informed in advance of locations where seam samples will be taken.
 - d. OWNER reserves right to increase frequency of testing in accordance with performance results of samples previously tested.
3. Sampling Procedures:
- a. Cut samples at locations chosen by GEOSYNTHETIC CQAC.
 - b. GEOSYNTHETIC CQAC shall number each sample and record sample number and location in panel layout drawing.
 - c. Repair holes in geomembrane resulting from destructive seam sampling immediately in accordance with repair procedures described in this Specification.
 - d. Continuity of repair and seams shall be tested in accordance with vacuum testing requirements.
4. Sample Dimensions: Take two 1-in. wide samples for field testing prior to cutting full laboratory sample.
- a. Field Testing: Cut 1 in. wide samples, 6 inches long with seam centered parallel to width. Distance between these 2 samples shall be 42 in. Test both samples on field tensiometer in peel. If both samples pass field test, take sample for laboratory testing.
 - b. Laboratory Testing: Take laboratory test sample from between samples taken for field testing. Cut sample for laboratory testing 12 in. wide by a minimum 42 in. long with seam centered lengthwise. Cut this sample into three parts. GEOSYNTHETIC CQAC shall distribute parts as follows:
 - i. One part to INSTALLER for optional laboratory testing, a minimum 12 in. by 12 in.

- ii. One part to Geosynthetic Quality Assurance Laboratory for testing, a minimum 12 in. by 18 in.
 - iii. One part to OWNER for archive storage, a minimum 12 in. by 12 in.
 - c. Final determination of sample sizes shall be agreed upon at pre-construction meeting.
 - d. Submit laboratory sample for quantitative testing
- 5. Destructive Test Failure Procedures:
 - a. When a sample fails destructive testing, whether test is conducted by the Geosynthetic QAL or by field tensiometer, CONTRACTOR has following options:
 - b. Repair seam between any 2 passing destructive test locations.
 - c. Trace welding path to intermediate point (10 ft minimum from point of failed test in each direction) and take small sample with 1 in. wide die for an additional field test at each location. If these additional samples pass test, then take full laboratory samples. If the laboratory samples pass tests, repair seam between these locations. If either sample fails, repeat process to establish zone in which seam should be repaired.
 - d. Acceptable repaired seams shall be bound by 2 locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of repaired seam, GEOSYNTHETIC CQAC may have INSTALLER destructively test repair seam.
 - e. When the sample fails, OWNER may require additional testing of seams that were welded by same welder and/or welding apparatus during same time shift.
- E. Repair Verification:
 - 1. GEOSYNTHETIC CQAC shall observe number and log each repair.
 - 2. Nondestructively test each repair.
 - 3. Nondestructive test results that pass shall indicate adequate repair.
 - 4. Repairs more than 150 ft long require destructive test sampling.
 - 5. Failed destructive or nondestructive tests indicate that repair shall be redone and retested until passing test results.

- F. Large Wrinkles: Wrinkle is considered to be large when geomembrane can be folded over onto itself.
1. When seaming of geomembrane is completed, and prior to placing overlying materials, GEOSYNTHETIC CQAC shall identify all excessive geomembrane wrinkles, which should be cut and resealed.
 2. Cut and reseam all wrinkles identified by GEOSYNTHETIC CQAC. Seams produced while repairing wrinkles shall be nondestructively tested.
 3. Repair wrinkles identified by GEOSYNTHETIC CQAC. Repair during coldest part of installation period.

* * * * * END OF SECTION * * * * *

SECTION 310519.16c

XR-5 GEOMEMBRANE

PART 1 – GENERAL

1.01 Work Included

- A. This Section includes the specifications and guidelines for the manufacture, installation, and testing of XR-5 geomembrane.

1.02 References

- A. Construction Quality Assurance Plan
- B. Latest version of the following standards:
 - 1. ASTM D 751 – Standard Test Methods for Coated Fabrics
 - 2. ASTM D 4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
- C. Additional references may be required based on manufacturer warranty requirements.

1.03 Submittals

- A. Pre-Installation
 - 1. Manufacturer's quality control results/certificates
 - 2. Manufacturer's specification for geomembrane
 - 3. Field panel layout
 - 4. Resumes of geomembrane superintendent and installers
 - 5. List of personnel performing installation
- B. Installation
 - 1. Subgrade surface acceptance certification
 - 2. Quality control documentation recorded during installation
 - 3. Material and installation warranties from manufacturer and installer

1.04 Pre-Qualifications

- A. Manufacturer/Fabricator

1. Manufacturer shall have successfully produced a minimum of 2,000,000 ft² that conforms to the manufacturer's specifications.
 2. Fabricator shall have successfully assembled a minimum of 2,000,000 ft² of XR-5 sheet specifically for the purpose of containment.
- A. Installer
1. Installer shall be approved by OWNER and have at least of 5 years of continuous experience in installation of EPDM geomembrane, or experience totaling 2,000,000 ft² of installed XR-5 geomembrane for at least 10 completed facilities.
 2. Installer shall be a member of the International Association of Geosynthetic Installers (IAGI).
 3. Installation personnel shall be qualified by experience or applicable tests.

1.05 Quality Assurance Program

- A. Manufacturer, fabricator, and installer shall participate in and conform to the items and requirements of quality assurance program as outlined in this Specification and the Quality Assurance Plan.
- B. Quality assurance shall be conducted in a manner that complies with the manufacturer's warranty requirements. CONTRACTOR shall provide a demonstration that the proposed methods comply with the manufacturer's warranty program.
- C. Upon delivery, the XR-5 geomembrane shall be visually inspected for defects, such as pinholes, blisters, etc. Additionally, the geomembrane shall be visually inspected to ensure uniform color, thickness, and texture.

1.06 Delivery, Storage, and Handling

- A. Packing and Shipping
 1. Manufacturer shall identify each package or roll delivered to site with the following:
 - a. Manufacturer's name.
 - b. Product Identification.
 - c. Thickness.
 - d. Identification number.
 - e. Dimensions.
 2. Protect geomembrane from excessive heat, cold, puncture, cutting, or other damaging or deleterious conditions during loading, transport, and unloading at site.

B. Acceptance at Site.

1. Conduct surface observations of each roll for defects and damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected.
2. Defected or damaged rolls or portions of rolls will be rejected and shall be removed from the Project Site and replaced with new rolls.
3. Rolls or portions of rolls without proper identification or labeling will be rejected and shall be removed from the Project Site.

C. Storage and Protection.

1. OWNER will provide on-site storage area for geomembrane rolls from time of delivery until deployment.
2. Installer shall protect geomembrane from dirt, water, and other sources of damage.
3. Preserve integrity and readability of geomembrane roll labels.
4. Rolls which do not have proper identification at delivery will not be accepted.

PART 2 – PRODUCTS

2.01 Materials

- A. The XR-5 geomembrane shall be Seaman’s 8138 XR-5 geomembrane or approved alternate, and shall conform to the criteria below. Manufacturer quality control testing will be performed in accordance with manufacturer specifications, and quality assurance testing will be conducted in accordance with the criteria contained in section 3.03 of this specification.

Testing Properties	Testing Method	Units	Test Value	Frequency
Thickness	ASTM D751	mils	40 (36 min.)	per 36,000 ft ²
Weight	ASTM D751	oz/yd ²	38.0 ± 2.0	per 36,000 ft ²
Tear Strength (trap tear)	ASTM D4533	lb	40/55 ¹	per 36,000 ft ²
Yield Strength (Break), grab tensile	ASTM D751	lb	550/550 ²	per 36,000 ft ²
Puncture Resistance	ASTM D4833	lb	200 (min.)	per 36,000 ft ²

1. The first number represents the average of all five specimens in both warp and filling directions (10 tests), and the second number represents the average of the five highest peak loads (not including the initial peak loads) for the five test specimens (warp or filling direction).
2. The first number represents the average longitudinal break strength and the second number represents the average transverse break strength.

- B. Construction quality assurance (CQA) testing for the geomembrane material shall be performed for the same properties shown above, but at a frequency of one test per 200,000 ft² of installed geomembrane.

PART 3 – EXECUTION

3.01 Preparation

A. Subgrade

1. Subgrade Characteristics:

- a. The subgrade shall contain no sharp edges, loose material, oil/grease, or other materials which may damage the XR-5 geomembrane.
- b. All subgrade voids greater than 0.25 inches shall be properly filled with an acceptable fill material.
- c. The subgrade shall be free of sticks, particles greater than 0.5” in diameter, and other materials which may damage the geomembrane.
- d. The subgrade shall contain no more than 1% organic matter (visual inspection).
- e. The subgrade shall be free of standing water, mud, snow, or excessive moisture.

2. Liner subgrade shall be compacted as detailed in Section 310000 – Earthwork.

3. CONTRACTOR is responsible for preparing the liner subgrade, and shall maintain the subgrade through installation of the liner. Damage to the prepared subgrade shall be accomplished at CONTRACTOR’s expense.

4. Liner may not be placed on the subgrade prior to approval of the subgrade in accordance with the Quality Assurance Plan.

3.02 Installation

A. Geotextile material shall be placed directly on the subgrade to serve as a cushion for the geomembrane. The geotextile should be at least 8 oz/yd².

B. The geomembrane shall be placed in a relaxed condition free from tension; however, wrinkles shall be minimized. The geomembrane shall not be stretched.

C. Panel Layout

1. Anchor trench

a. The anchor trench shall be dug along the perimeter of the proposed pond in accordance with the design drawings.

b. The top-of-slope runout length to the anchor trench shall be at least 3 feet.

2. Adequate care shall be taken when unrolling and placing geomembrane to prevent damage from puncture, tearing, etc. Installer will repair damaged geomembrane at Installer's expense.

D. Seaming

1. Seaming shall be accomplished in accordance with manufacturer specifications.
2. Trial seams shall be tested for each welding machine prior to conducting seaming operations.
3. A minimum of 6 inches of overlap shall be maintained between adjacent liner sections.
4. Both the factory seams and field seams shall conform to the following criteria:

Testing Properties	Testing Method	Units	Test Value	Frequency
Adhesion (Heat-welded seam)	ASTM D751	lb/2in	40	per 500 ft
Bonded Seam Strength – Procedure A, grab method	ASTM D751	lb	550	per 500 ft

3.03 Quality Assurance

- A. Quality assurance shall be conducted in accordance with manufacturer's warranty requirements and the Quality Assurance Plan (CQA Plan). In cases where the CQA Plan or these specifications disagree with manufacturer's warranty requirements, the warranty requirements will take precedence.
- B. All field seams, patches, and other appurtenances shall be non-destructively tested using the air lance method (ASTM D4437).
- C. Destructive sampling shall be conducted for all field seams, at intervals not exceeding 500 feet. Destructive sampling shall be conducted as follows:
 1. A sample approximately 12 inches wide and 5-6 feet long shall be cut from the seam. The sample should be centered on the seam.
 2. Each sample shall be labeled with the identification, location, panel numbers, and seam number. The sample date, time, welding technician, and ambient temperature should also be recorded.
 3. Each sample will be cut into three sections of approximately 2 feet in length. One section will be sent to a third party laboratory for testing, one section will be presented to the owner for archiving, and one section will be retained by the installer.

4. The samples shall be tested in accordance with Procedure A (Grab Test Method) of ASTM D751. The 2-foot section will be cut into five equivalent specimens for testing.
5. Four of the five specimens must meet the minimum seam strength requirements for the seam to pass. The lowest strength must not be less than 80% of the required bonded seam strength shown in section 3.02 above.
6. Failed seams will be traced outward from the sample location (in both directions) until the samples meet the minimum strength requirements.

* * * * * END OF SECTION * * * * *

SECTION 310519.26

GEONET COMPOSITE

PART 1 – GENERAL

1.01 Work Included

- A. The work of this section shall include all labor and Materials and Equipment to furnish and install the geonet composite in the location and to the dimensions shown on the construction drawings as directed or as approved by the OWNER or OWNER'S ENGINEER.

1.02 Related Work

- A. Carefully examine all of the contract documents for requirements that affect the Work.
- B. Other specification sections that contain requirements that relate to the Work included in this section include, but are not limited to, the following:
 - 1. Earthwork – Section 310000
 - 2. HDPE Geomembrane – Section 310519.16

1.03 References

- A. American Society of Testing and Materials (ASTM)
 - 1. ASTM D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
 - 2. ASTM D1505 Standard Test Method for Density of Plastics by the Density – Gradient Technique
 - 3. ASTM D1603 Standard Test Method for Carbon Black in Olefin Plastics
 - 4. ASTM D4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
 - 5. ASTM D4491 Water Permeability of Geotextile by Permittivity
 - 6. ASTM D4716 Standard Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
 - 7. ASTM D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile

8. ASTM D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
 9. ASTM D5035 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
 10. ASTM D5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
 11. ASTM D5261 Standard Test Method for Measuring the Mass per Unit Area of Geotextiles
 12. ASTM D5321 Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Interface Friction by the Direct Shear Method
- B. Geosynthetics Research Institute (GRI)
1. GRI GC-7 Determination of Adhesion and Bond Strength of Geocomposites

1.04 Submittals

- A. No material shall be delivered to the Project Site until the material and performance documentation and certifications have been received and reviewed by OWNER and the OWNER'S ENGINEER. In addition, no material shall be delivered until the interface shear testing has been completed and the material has been approved by the OWNER and OWNER'S ENGINEER.
- B. The manufacturer shall supply the Owner and CQA Consultant with samples of the geonet composite taken from rolls that will be delivered to the site to complete pre-delivery/pre-construction interface shear testing. Each sample must be properly identified to include: manufacturer, model, lot, and roll numbers.

1.05 Labeling, Delivery, Storage, and Handling

- A. Labeling – Each roll of geonet composite delivered to the Project Site shall be labeled by the Manufacturer. The label shall clearly state the manufacturer's name, product identification, length and width, and roll number. The label shall be found on either of the end caps, an inside edge of the core, and outside the core.
- B. Delivery – The rolls of geonet composite shall be packaged and shipped by appropriate means to prevent damage to the material and to facilitate off-loading.

- C. Storage – Prior to mobilization of the installer, the CONTRACTOR shall be responsible for all on-site storage of the geonet composite material. Once the Installer has mobilized on-site, all storage of the geonet composite material shall be the responsibility of the Installer. The CONTRACTOR/Installer shall provide a suitable storage site that will protect the geonet composite from punctures, abrasions, excessive moisture, and dirt. The on-site storage location for the geonet composite material should be level, smooth, elevated, and dry. The geonet composite shall not be stored on wooden pallets. The storage place should be protected from theft and vandalism and, if possible, should be adjacent to the area to be lined to facilitate installation and minimize handling. Geonet composite rolls shall be stockpiled for storage no more than four rolls high or as approved in writing by the manufacturer.
- D. Handling – Prior to mobilization of the installer, the CONTRACTOR shall be responsible for all on-site handling of the geonet composite material. Once the Installer has mobilized on-site, all handling of the geonet composite material shall be the responsibility of the Installer. The materials are to be handled so as to prevent damage. The CONTRACTOR responsible for off-loading of the geonet composite material shall contact the manufacturer prior to delivery to confirm transport type, equipment, and procedures necessary for proper handling. Instructions for moving geonet composite rolls shall be provided by the manufacturer upon request.

1.06 Quality Control

- A. The Contractor shall have an individual experienced in the installation of geonet composite on-site at all times during the installation. The designated individual shall be responsible for assuring that the geonet composite is installed according to this specification and the construction drawings. The appointment shall be subject to approval by the OWNER.

1.07 Quality Assurance

- A. The installer shall be approved by OWNER and have at least five years of experience with geonet composite installation. In addition, the Installer shall have completed a minimum of five projects with the same material and of similar scope to that indicated for this Project. The installer shall have a successful installation and maintenance record of in-service performance.
- B. The CONTRACTOR is required to demonstrate compliance to the above requirements to the satisfaction of the OWNER and OWNER’S ENGINEER.
- C. The OWNER may engage the services of a CQA Consultant and testing laboratory to monitor the geonet composite installation and complete conformance testing.
- D. Quality assurance (QA) samples of geonet composite shall be collected by the Owner, CQA Consultant or OWNER’S ENGINEER upon delivery and tested for the properties listed and frequencies given in Table 1.

1.08 Warranty

- A. Material shall be warranted on a pro-rata basis against manufacturer's defects for a period of two years from the date of geonet composite installation completion.
- B. Installation shall be warranted against defects in workmanship for a period of two years from the date of geonet composite installation completion.

PART 2 – PRODUCTS

2.01 Geonet Composite Properties

- A. The HDPE geonet composite shall be a 250 mil geonet with an 8 oz/yd² non-woven geotextile fabric heat bonded to both sides and shall have properties that meet or exceed values presented in Section 3.05, Table 1.
- B. The resin shall be new first quality, compounded polyethylene resin. The natural resin (without carbon black) shall meet the minimum requirements presented in Section 3.05.
- C. Geonet composite material shall meet the following interface friction angle requirements under the following test conditions.
 - 1. The minimum required interface friction angle between the proposed geonet composite and the proposed textured geomembrane is 18.5 degrees, or as otherwise approved by OWNER and the OWNER'S ENGINEER. The test shall be conducted under saturated conditions with normal loads of 100 psf, 300 psf, and 500 psf, a shear rate of 0.04 in/min, a seat time of 15 minutes, and a saturation time of 15 minutes.
 - 2. The minimum required interface friction angle between the geonet composite and the proposed soil protective cover is 24 degrees, or as otherwise approved by OWNER and the OWNER'S ENGINEER. The test shall be conducted under saturated conditions with normal loads of 100 psf, 300 psf, and 500 psf, a shear rate of 0.04 in/min, a seat time of 15 minutes, and a saturation time of 15 minutes.
 - 3. The testing laboratory shall be an independent laboratory accredited to conduct ASTM D5321 in accordance with the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI – LAP) at the time of testing.
 - 4. CONTRACTOR shall prepare a test report that addresses complete test details, procedures, and results. The report shall be submitted to OWNER and the OWNER'S ENGINEER at least six weeks prior to placement.

PART 3 – EXECUTION

3.01 Installation Of Geonet Composite

- A. Surface Preparation

1. Prior to commencing any work, the Installer shall carefully inspect the surface and verify that it is clean of all soil, rock, water, and other material that could damage the geonet composite. The CONTRACTOR shall verify that all Work is complete to the point where installation of the geonet composite may properly commence without adverse impact.

B. Placement

1. The geonet composite roll shall be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by OWNER and the OWNER'S ENGINEER.
2. On long, steep slopes, special care should be taken so that only full length rolls are used at the top of the slope. The geonet composite shall be unrolled downslope keeping the net in slight tension to minimize wrinkles and folds.
3. The installer shall deploy the geonet composite ensuring that the geonet composite and underlying materials are not damaged. Faulty or damaged geonet composite shall be replaced or repaired as specified in Section 3.02.
4. The geonet composite shall be properly anchored at the anchor trench to resist sliding. Anchor trench compaction equipment shall not come into direct contact with the geonet composite.
5. The geonet composite shall be maintained free of dirt, mud, or any other foreign materials at all times during construction. Rolls that are contaminated with these materials shall be cleaned or replaced.
6. Adequate ballast (e.g. sandbags) shall be placed to prevent uplift by wind. Spacing shall be determined by the Installer. Any damage caused by wind uplift shall be the responsibility of the CONTRACTOR and shall be corrected at no cost to the OWNER.

C. Overlap and Fasteners

1. Adjacent rolls shall be overlapped a minimum of six inches. Fasteners, as recommended by the manufacturer and approved by the OWNER and OWNER'S ENGINEER, shall be used to join adjacent rolls. Metallic fasteners will not be allowed. Fasteners shall be spaced a maximum of five feet along downslope roll overlaps, a maximum of two feet along cross-slope roll overlaps and a maximum of six inches in an anchor trench. Fasteners shall be of contrasting color from the geonet composite to facilitate visual inspection.

D. Stacked Geonet Composite Layers

1. Stacking of geonet composite layers more than two layers thick shall not be permitted.

E. Seams

1. Each component of the geonet composite will be secured or seamed to the like component at overlaps. The upper geotextile on adjacent panels of geonet composite shall be sewn or heat bonded together with a continuous seam. The adjacent sheets of geotextile shall be overlapped a minimum of six inches. All overlaps shall be installed such that the upslope sheet is placed over the downslope sheet.

F. Geonet Components

1. Adjacent edges of the geonet along the length of the geonet composite roll shall be placed with the edges of each geonet butted against each other. Adjoining geonet composite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geonet composite a minimum of 12 inches across the roll width.

3.02 Repairs

- A. Holes or tears in the geonet composite shall be repaired by placing a patch of geonet composite extending a minimum of two feet beyond the edges of the hole or tear. Approved fasteners, spaced every six inches around the patch, shall be used to fasten the patch to the original roll.
- B. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out, and the two portions of the geonet composite shall be joined in accordance with Section 3.01.C.

3.03 Penetrations

- A. Geonet composite penetration details shall be as recommended by the Manufacturer and as approved by the OWNER and OWNER'S ENGINEER.

3.04 Cover

- A. Upon completion and acceptance by the OWNER and OWNER'S ENGINEER of the geonet composite in an area, the material shall be covered within 14 days of acceptance.

3.05 Sampling And Testing

- A. The following sampling and testing shall be completed and submitted in accordance with the CQA Plan.
- B. Manufacturer's shall provide material certificates of compliance and certified test reports at sampling frequencies specified in Tables 1, 2, and 3. In addition, the OWNER and CQA Consultant shall collect QA conformance samples of geonet composite upon delivery for the properties listed and frequencies given.

Table 1: Minimum Average Roll Values (MARV) for Geonet Composite

Property	Test Method	Testing Frequency		MARV
		Manufacturer Quality Control (QC)	Quality Assurance (QA)	
Transmissivity (m ² /sec) ¹	ASTM D4716	1 per project	1 per project	5.0 x 10 ⁻⁴
Ply Adhesion, minimum (lb/in)	GRI GC-7	1 per 100,000 ft ²	1 per 250,000 ft ²	1.0

1. Gradient of 0.1, normal load of 10,000 psf, water at 70° F, between stainless steel plates and at a 15-minute seat time.

Table 2: MARV for Geonet Composite - Geonet Component

Property	Test Method	Testing Frequency		MARV
		MQC	QA	
Thickness (mil)	ASTM D5199	1 per 100,000 ft ²	NA	250
Density (g/cm ³)	ASTM D1505	1 per 100,000 ft ²	NA	0.94
Tensile Strength (ppi)	ASTM D5035	1 per 100,000 ft ²	NA	55
Carbon Black Content (%)	ASTM D1603	1 per 100,000 ft ²	NA	2.0

Table 3: MARV for Geonet Composite - Geotextile Component

Property	Test Method	Testing Frequency		MARV
		MQC	QA	
Mass per Unit Area (oz/yd ²)	ASTM D5261	1 per 100,000 ft ²	NA	8
Apparent Opening Size (US Sieve)	ASTM D4751	1 per 540,000 ft ²	NA	70
Flow Rate (gpm/ft ²)	ASTM D4491	1 per 540,000 ft ²	NA	90
Grab Tensile (lb)	ASTM D4632	1 per 100,000 ft ²	NA	200
Puncture Strength (lb)	ASTM D6241 or ASTM D4833	1 per 100,000 ft ²	NA	400 (D6241) or 100 (D4833)

1. Component properties prior to lamination.

END OF SECTION

SECTION 311100

SITE CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 Description Of Work

- A. The CONTRACTOR shall furnish all Materials and Equipment, labor, Construction Aids, tools and appurtenances required to complete the Work.
- B. Project Site clearing includes, but is not limited to, removing from the limits of work and disposing of trees, stumps, roots, brush, structures, abandoned utilities, trash, asphalt, debris and all other materials found on or near the surface of the ground in the construction area. Precautionary measures that prevent damage to existing features to remain are part of the Work.
- C. Comply with all Laws and Codes.
- D. No clearing and grubbing will be allowed without adequate erosion and sedimentation control measures in place and to the satisfaction of the OWNER and OWNER'S ENGINEER.

1.02 Related Sections

- A. Temporary Erosion and Sediment Control – Section 015713
- B. Dust Control - Section 015726
- C. Earthwork – Section 310000

1.03 Job Conditions

- A. Location of the Work: The area to be cleared and grubbed includes all areas designated for pipe laying and installation of system components.

PART 2 - PRODUCTS

The CONTRACTOR shall furnish equipment of the type normally used in clearing and grubbing operations including, but not limited to, dozers, shears, skidders, loaders, root rakes, chipping equipment, and stump grinders.

PART 3 - EXECUTION

3.01 Scheduling Of Clearing

- A. CONTRACTOR shall install the soil erosion and sedimentation control measures in accordance with the "Soil Erosion and Sediment Control Plan" approved by OWNER and OWNER'S ENGINEER per Section 015713 – Temporary Erosion and Sediment Control.

- B. CONTRACTOR shall maintain all survey controls.

3.02 Construction Area Clearing And Grubbing

- A. Materials to be cleared, grubbed, and removed from the construction areas include, but are not limited to, the following: all trees, stumps, roots, brush, trash, organic matter, miscellaneous structures, debris, and abandoned utilities.
- B. Grubbing shall consist of completely removing roots, stumps, trash and other debris from all graded areas so that surface material is free of roots and debris. Surface material is to be left sufficiently clean so that further picking and raking will not be required.
- C. All stumps, roots, foundations, and planking embedded in the ground shall be removed and disposed.
- D. CONTRACTOR shall take precautions when removing stumps, roots, or other material embedded in the ground to minimize the disturbance and surface spread of any Coal Combustion Residual (CCR) material below. Where root balls and other deleterious items for removal from the existing soil are observed to contain CCR, the Contractor shall segregate the material into the CCR-mixed stockpile area (*see* Section 3.04 below).
- E. Surface rocks and boulders shall be grubbed from the soil and removed to the area on-site as directed by the OWNER.
- F. All construction areas shall be grubbed by tractors with root rakes.
- G. Where tree limbs interfere with utility wires, or where the trees to be felled are in close proximity to utility wires, the tree shall be taken down in sections to eliminate the possibility of damage to the utility. The CONTRACTOR shall be responsible for damages to utilities and shall replace/repair damaged utilities at no cost to OWNER.
- H. Any work pertaining to utility poles and guy wires shall comply with the requirements of the appropriate utility.
- I. After removing small growth less than 6 inches in diameter in the staging area, the CONTRACTOR shall protect all existing growth larger than 6 inches in diameter. Any potential growth damaged by the CONTRACTOR shall be replaced with vegetation of similar species and size as approved by the OWNER at no cost to the OWNER.
- J. Stumps and roots shall be grubbed and removed to a depth not less than two feet below grade. All holes or cavities which extend below the subgrade elevation of the proposed work shall be filled with on-site soil, compacted to a similar density as the surrounding material.
- K. The CONTRACTOR shall exercise special precautions for the protection and preservation of trees and shrubs situated adjacent to the limits of the construction area. The CONTRACTOR shall be held liable for any damage the CONTRACTOR's operations have inflicted on such property.
- L. The CONTRACTOR shall be responsible for all damages to existing structures and/or improvements resulting from CONTRACTOR's operations.

3.03 Overhead Utility Line Right Of Way Clearing

- A. All tree trimming operations within the right of way of overhead utility lines shall be completed in accordance with the requirements of the utility owner.
- B. Trees at edge of right of way shall be side-walled ground to sky.
- C. Stumps shall be cut to within 3" of ground level.
- D. Brush shall be chipped and windrowed out of right of way, or ground up with a brush hog in the right of way.
- E. No wood shall be left in right of way (stack it out of right of way).

3.04 Disposal Of CCR-Mixed Debris

- A. Grubbed material that is covered with, ingrown, or otherwise mixed with CCR shall be placed in a separate stockpile that is established within the bounds of the existing CCR facility.
- B. Non-wood CCR-mixed debris shall be roughly cleaned of large quantities of CCR (broom clean or equivalent) prior to removal from the Project Site for disposal in an off-site approved disposal facility.
- C. CCR-mixed debris consisting of wood (stumps, roots, etc.) may be removed from the Project site or disposed in one or more of the following ways, subject to OWNER'S approval:
 - 1. Ground into chips and hauled to an OWNER-approved biomass facility for use as fuel;
 - 2. Material to be roughly cleaned of large quantities of CCR (broom clean or equivalent) prior to removal from site for disposal in an off-site approved disposal facility.

3.05 Disposal Of Non-CCR Mixed Debris

- A. All non-CCR mixed wood debris (stumps, roots, branches, and leaves) resulting from the clearing and grubbing operation shall be disposed of by disposal off-site or by other methods as approved by OWNER, in accordance with the Contract drawings and Specifications.
- B. All large debris, pipe, large metal objects, and bulky items will be removed and hauled to an off-site approved disposal facility.

3.06 Quality Assurance

- A. The CQA Consultant shall observe the stripping and stockpiling of existing soils to identify when CCR materials are encountered. The CQA Consultant shall identify the extent of the CCR material and verify the CONTRACTOR does not place unsuitable material into the soil stockpile.

* * * * * END OF SECTION * * * * *

SECTION 312319

CONSTRUCTION DEWATERING

PART 1 - GENERAL

1.01 Description Of Work

- A. This section specifies the requirements for the Work related to the handling and management of dewatering activities.
- B. CONTRACTOR shall design, construct, and maintain all dikes, sumps, and diversion and drainage channels as necessary to complete the Work and to protect the areas to be occupied by permanent work from water damage. CONTRACTOR shall remove temporary works after they have served their purpose.
- C. CONTRACTOR shall be responsible for the stability of all temporary and permanent slopes, grades, foundations, materials, and structures during the course of the Contract. Repair and replace all slopes, grades, foundations, materials, and structures damaged by water, both surface and subsurface, to the lines, grades, and conditions existing prior to the damage, at no additional cost to OWNER.
- D. CONTRACTOR shall provide a Competent Person to implement and supervise all Work.
- E. The CONTRACTOR shall submit a description of its methods for accomplishing construction dewatering to OWNER and OWNER'S ENGINEER for approval.
- F. CONTRACTOR shall provide measures to minimize accumulation of surface water at the Project Site.
- G. CONTRACTOR will segregate all surface runoff and waters from perched groundwater and seeps encountered by CONTRACTOR during excavation and filling operations. Perched groundwater and seeps encountered by CONTRACTOR will be collected, pumped, transferred and hauled to an on-site discharge point as directed by OWNER.

1.02 Related Sections

- A. Temporary Erosion and Sediment Control – Section 015713
- B. Earthwork – Section 310000
- C. Shoring and Bracing – Section 314100

PART 2 - PRODUCTS

Piping, pumping equipment, and all other equipment and materials required for dewatering shall be suitable for the intended purpose. Standby pumping units shall be maintained at the Project Site to be used in case of failure of the normal pumping units.

PART 3 - EXECUTION

3.01 Handling Of Water

- A. Design, furnish, install, maintain, monitor, operate, and remove necessary pumping and other equipment for dewatering the various parts of the Work and for maintaining the work areas free from water as required for constructing each part of Work.
- B. Install all drainage ditches, sumps, and pumps to control excessive seepage on excavated slopes, to drain isolated zones with perched water tables and to drain impervious surfaces at final excavation elevation.
- C. Water shall be filtered by a dewatering structure to remove sediment prior to discharge by means of a filter box, sediment tank, Dirtbag®, or other means compliant with the Virginia Erosion and Sediment Control Handbook.
- D. Dewater by means which will enable completion of the Work and preserve final lines and grades. Do not disturb or displace adjacent soil.
- E. All pumping and drainage shall be done with no damage to property or structures and without interference with the rights of the public, owners of private property, pedestrians, vehicular traffic or the Work of other contractors, and in accordance with all Laws and Codes.
- F. Do not overload or obstruct existing drainage facilities.
- G. Separate all surface runoff water and segregate and collect all water from perched groundwater and seeps that may be encountered during excavation or site grading. Collect, segregate, hold and dispose of water collected from perched groundwater and seeps separately from surface runoff.
- H. After they have served their purpose, remove all temporary protective work at a time and in a manner approved by the OWNER. All temporary diversion channels and other temporary excavations in areas where the compacted fill or other structures will be constructed shall be cleaned out, backfilled and processed under the same specifications as those governing the compacted fill (Section 310000).
- I. When the temporary works will not adversely affect any item of permanent work on the planned usage of the Project, CONTRACTOR may be permitted to leave such temporary works in place. In such instances, breaching of dikes and other temporary works may be required.

3.02 Dewatering

- A. By the use of pumps, tile drains or other approved methods, CONTRACTOR shall control the flow and accumulation of water in excavated areas to prevent excessive softening and disturbance of exposed soils in excavations as necessary for completion of the Work.

- B. The system used shall not cause settlement damage to adjacent structures. The CONTRACTOR shall carry out the Work by the use of other methods which will not endanger adjacent structures; all such Work shall be done at the CONTRACTOR's expense.
- C. Disposal of all dewatering liquids shall follow the sites NPDES permit and be in accordance with all Laws and Codes.

* * * * * END OF SECTION * * * * *

SECTION 313700

STONE RIPRAP

PART 1 - GENERAL

1.01 Description Of Work

- A. The CONTRACTOR shall provide all labor, Materials and Equipment, Construction Aids, tools and appurtenances required to complete the Work of furnishing and placing stone riprap, as shown, specified or required.
- B. Comply with all Laws and Codes.

1.02 Related Sections

- A. Temporary Erosion and Sedimentation Control – Section 015713
- B. Geotextile – Section 310519.13

PART 2 - PRODUCTS

2.01 Material

- A. Stone riprap shall consist of hard, durable, subangular material. It shall be free from any considerable amount of flat, laminated, or elongated particles; and shall be free from cracks, overburden shells, clay, organic matter, or other deleterious matter.
- B. The riprap shall be composed of an evenly distributed mixture such that 50 percent of the mixture by weight shall be larger than the d_{50} size as indicated on the Contract Drawings. The diameter of the largest stone size in such a mixture shall be at least 2.0 times the d_{50} size. The diameter of the smallest stone size in such a mixture shall be greater than 0.5 times the d_{50} size.
- C. The breadth or thickness of a single stone shall not be less than 1/3 its length.
- D. Crushed concrete meeting the gradation requirements shall be an acceptable substitute for stone riprap.

2.02 Submittals

- A. Submit manufacturer's certification of material properties as outlined in Part 2 to the OWNER and OWNER'S ENGINEER.

PART 3 - EXECUTION

3.01 Installation – Loose Riprap

- A. Stone riprap shall be placed to thicknesses as indicated on Contract drawings. Nonwoven Geotextile shall be placed under all riprap unless otherwise indicated on the Contract drawings.
- B. Stone riprap shall be placed in a manner that will not damage geotextile, synthetics, utilities or other facilities. Riprap shall not be dropped from a height exceeding three feet.
- C. The tolerance in riprap thickness in place shall be -0 to +0.3 feet.
- D. No material shall be placed in areas not indicated as such on the Contract drawings unless approved by or directed by the OWNER.

3.02 Installation – Grouted Riprap

- A. Grout shall consist of 1 part hydraulic cement and 3 parts sand, thoroughly mixed with water to produce grout having a thick, creamy consistency.
- B. Stones shall be of the same sizes and placed in the same manner as specified for dry riprap, Class I. Care shall be taken during placing to keep earth or sand from filling spaces between stones. After stones are in place, spaces between them shall be filled with grout from bottom to top and the surface swept with a stiff broom.
- C. Riprap shall not be grouted in freezing weather. In hot, dry weather, the work shall be protected from sunlight and kept moist for at least 3 Days after grouting by the use of saturated burlap or other suitable method.

* * * * * END OF SECTION * * * * *

SECTION 314100

SHORING AND BRACING

PART 1 - GENERAL

1.01 Description Of Work

- A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the Work of shoring, bracing, and sheeting or sheet piling, necessary to complete the construction, protect structures, and prevent the loss of ground or caving of embankments, excavations, or cut slopes, as shown, specified or required, and shall meet all Laws and Codes. The CONTRACTOR shall provide a "Competent Person" as defined to implement, supervise, and inspect all shoring and bracing.
- B. CONTRACTOR shall be solely responsible for proper excavation procedures including, but not limited to, safe slope angles and the design and use of properly designed and installed shoring and bracing systems in accordance with OSHA and other Laws and Codes. As required, shoring and bracing shall be designed by the CONTRACTOR's engineer who is a registered professional engineer in the Commonwealth of Virginia. Remove all shoring and bracing without disturbing backfill, bedding, haunching, pipes or structures. The presence of the CQA Consultant, OWNER'S ENGINEER or OWNER shall not relieve the CONTRACTOR of his responsibility to properly design, install and maintain shoring and bracing. The OWNER shall not be the "Competent Person" on the Site.
- C. Pressures on sheeting and the stability of the sheeting and bottom of the excavation are dependent not only on soil conditions but upon many procedures and options available to the CONTRACTOR, such as dewatering, staging of excavation and installation of bracing, flexibility of sheeting, construction equipment used, and time of completing the Work. All such factors shall be considered and investigated as necessary in the design of the sheeting and bracing.
- D. Comply with applicable Laws and Codes.

1.02 Related References

- A. Recommended Technical Provisions for Shoring and Sloping of Trenches and Excavations, U.S. Department of Commerce.
- B. Construction Safety and Health Regulations, U.S. Department of Labor, Occupational Safety and Health Administration.
- C. Occupational Safety and Health Regulations- Excavations, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR Part 1926.

1.03 Related Sections

- A. Earthwork – Section 310000

1.04 Submittals

- A. In cases where the excavation cannot be open cut to a safe working angle in accordance with applicable requirements or where excavation may jeopardize adjacent site areas or the stability of nearby structures or facilities, the CONTRACTOR shall submit drawings, computations and substantiating data, prepared, signed, and sealed by a professional engineer licensed in the Commonwealth of Virginia, showing his proposed shoring and bracing design and method of construction for the information of the OWNER prior to the start of such Work.
- B. Shoring and bracing systems shall be designed such that removal shall not jeopardize work already performed. Shoring and bracing systems shall not remain permanently in place without the written approval of the OWNER.
- C. Any review or comments by the OWNER shall not relieve the CONTRACTOR of his responsibility for sheeting and bracing.
- D. In trenches, the sheeting shall be designed so that the lowest brace is no closer than 12 inches above the base of the structure to be installed.

1.05 Quality Control

- A. During the installation of the sheeting and bracing and as long as the excavation is open, the CONTRACTOR's Representative shall monitor the work to ensure that it is carried out in accordance with his design and procedures.

PART 2 - PRODUCTS

- A. All materials shall meet, or exceed, the minimum requirements of the applicable codes and those assumed in the design submitted by the CONTRACTOR.

PART 3 - EXECUTION

3.01 Verifying Existing Conditions

- A. Before commencing work, the CONTRACTOR shall check and verify all governing dimensions and elevations, including field measurements of existing and adjoining work on which his work is dependent, to assure proper fit and clearance of each part of the Work to the new and existing structures.

3.02 Coordination With Other Operations

- A. The schedule and progress of the shoring, bracing, and sheeting work shall be coordinated with the excavation and backfilling work. If, during the progress of the excavation, lateral movement of the surrounding soils, or any other evidence of instability is discovered, further excavation or backfilling work in the excavation shall cease and corrective measures shall be taken immediately to prevent further movement.

3.03 Removal Of Shoring And Bracing Materials

- A. Where the CONTRACTOR elects and is permitted not to remove shoring and bracing material, all such material shall be removed to the extent that the top of the material shall be a minimum of 5 feet below the proposed finished grade. No shoring or bracing may remain in place within the limits of the proposed geomembrane liner placement.
- B. Removal of shoring and bracing shall be carried out in a manner such that no structure shall be disturbed or damaged during or after removal. Protection of structures during the removal of shoring and bracing shall be the sole responsibility of the CONTRACTOR, and any disturbance or damage shall be rectified at no expense to the OWNER.

3.04 Safety

- A. Installation and removal methods of shoring and bracing shall meet, or exceed, the minimum requirements of the applicable codes and safety precautions as outlined in such codes, and shall be enforced by the CONTRACTOR.

* * * * * END OF SECTION * * * * *

SECTION 329119

VEGETATIVE SUPPORT LAYER

PART 1 - GENERAL

1.01 Work Included

- A. This Work shall consist of applying a final cover soil layer where applicable to support vegetation in accordance with the design drawings.

1.02 Related Sections

- A. Temporary Erosion and Sediment Control – Section 015713
- B. Earthwork – Section 310000
- C. Seeding – Section 329219

1.03 Quality Control

- A. CONTRACTOR shall provide vegetative support soil samples to the local agricultural agent, in size and quantity necessary, for testing and evaluation. The CONTRACTOR shall furnish and apply the types and quantities of soil conditioner, fertilizer, and seed as recommended by a local agricultural agent.

1.04 Submittals

- A. At least 14 Days prior to the proposed placement of vegetative support soil, the CONTRACTOR shall submit the test results and recommendation of the local agricultural agent to the Owner and CQA Consultant for review. Information on soil conditioner and/or fertilizer shall also be submitted, if they are recommended.

PART 2 - PRODUCTS

2.01 Materials

- A. Vegetative support soil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, and clay loam). It shall be free of debris, trash, stumps, rocks, roots and noxious weeds, and shall give evidence of being able to support plant growth. Topsoil shall have:
 - 1. Organic matter content not less than 1.5 percent by weight.
 - 2. pH range of 6.0 to 7.5.
 - 3. Soluble salts less than 500 ppm.
 - 4. No substance that is toxic to plant growth

PART 3 - EXECUTION

3.01 Preparing Areas To Receive Vegetative Support Soil

Unless otherwise directed by the OWNER, areas designated to receive vegetative support soil shall be graded, shaped, and then scarified or tilled by disking, harrowing, or other approved methods to a depth of approximately 2 inches. Soil shall be applied only when the subsoil is in a loose, friable condition.

Subsoil on slopes that have been horizontally grooved in accordance with the Contract drawings shall not be loosened.

3.02 Applying Vegetative Support Soil

The loose depth of topsoil shall be sufficient to restore the disturbed areas to their original condition.

Topsoil shall not be used in muddy or frozen conditions. After topsoil has been applied, large clods, hard lumps, and unacceptably large stones; brush; roots; stumps; litter, and foreign material shall be removed from the area. When the operation is complete, the area shall be in a condition to receive seed, sod, or plants without further soil preparation. Areas shall be seeded within 7 Days after topsoil is applied.

* * * * * END OF SECTION * * * * *

SECTION 329219

SEEDING

PART 1 – GENERAL

1.01 Work Included

- A. Furnish all labor, Construction Aids, Materials and Equipment and other incidentals required to establish seeding. This Work shall include maintenance of established vegetation until Demobilization. The CONTRACTOR shall be expected to provide and place all vegetative support soil necessary to complete the Work.
- B. CONTRACTOR shall revegetate all areas disturbed by his operations. All areas disturbed or not having sufficient vegetation to prevent erosion shall be revegetated.

1.02 Related Sections

- A. Temporary Erosion and Sediment Control – Section 015713
- B. Earthwork – Section 310000
- C. Vegetative Support Layer – Section 329119

1.03 Quality Assurance

- A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.04 Maintenance Data

- A. Submit maintenance data for continuing OWNER maintenance.
- B. Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer.

1.05 Delivery, Storage, And Handling

- A. Transport and handle products in accordance with the Manufacturer's instructions.
- B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging will not be acceptable.
- C. Promptly inspect shipments to assure that products comply with requirements, quantities are correct, and products are undamaged.
- D. Store and protect products in accordance with the Manufacturer's instructions with seals and labels intact and legible.

1.06 Temporary Vegetation

- A. Reference Std. & Spec. 3.31, Virginia Erosion and Sediment Control Handbook. When earth moving activities are completed more than 15 Days prior to installation of permanent control measures, or final grading is completed during a season not favorable for immediate establishment of permanent vegetation, stabilize with rapid growing annual grasses of a seasonally appropriate species. Provide species that allow quick protective cover and are compatible with future permanent measures.

1.07 Warranty

- A. CONTRACTOR shall provide a two-year warranty on all permanent seeding. If after a two-year period, a mature stand of grass vegetation is not established to the satisfaction of the OWNER, the CONTRACTOR shall be responsible for re-top soiling, fertilizing, seeding, and mulching any denuded areas. At which time, another one-year warranty shall be provided to the OWNER by the CONTRACTOR on the repaired areas. Retainage, as specified in the Contract Documents, withheld on seeding, shall not be released until the warranty period is over and the OWNER is satisfied with the final stand of vegetation.

PART 2 – PRODUCTS

2.01 Soil Materials

- A. Vegetative Support Layer: Soils capable of sustaining vegetative growth either excavated from site or imported material and free of weeds as specified in Technical Specification Section 329119.

2.02 Accessories

- A. Mulching material: Oat or wheat straw, dry, free from weeds and foreign matter detrimental to plant life.
- B. Lime: Lime shall comply with applicable Virginia Laws and Codes and shall be delivered in unopened bags or other convenient standard containers, each fully labeled with the Manufacturer's guaranteed analysis. Lime shall be ground limestone containing not less than 85 percent total carbonates and shall be ground to such fineness that 90 percent by weight will pass through a No. 20 mesh sieve and 50 percent by weight will pass through a No. 100 mesh sieve.
- C. Fertilizer: Fertilizer shall comply with applicable Virginia Laws and Codes and shall be delivered in unopened bags or other convenient standard container, each fully labeled with the manufacturer's guaranteed analysis. Fertilizer shall contain not less than 10 percent nitrogen, 10 percent available phosphoric acid and 10 percent water soluble potash (N-P-K, 10-10-10). Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable and shall be immediately removed from the Project Site.

PART 3 – EXECUTION

3.01 General

- A. Areas to be seeded include all areas disturbed during construction that are not to be paved.
- B. Verify that prepared soil base is ready to receive the Work.

3.02 Fertilizer and Lime

- A. Apply lime and fertilizer according to soil tests, or apply lime at the rate of 90 lbs./1000 ft², and fertilizer at the rate of 23 lbs./1000 ft².
- B. Mix thoroughly into upper four inches of topsoil.
- C. Lightly water to aid the dissipation of fertilizer and lime.

3.03 Seedbed Preparation

- A. Prepare seedbed to a depth of four to six inches.
- B. Remove loose rocks, roots, and other obstructions so that they will not interfere with the establishment and maintenance of vegetation.

3.04 Temporary Seeding

- A. Provide temporary seeding on any cleared, non-vegetated, or sparsely vegetated soil surface where vegetative cover is needed for less than one year or when seeding dates will prevent the establishment of vegetative cover if permanent seeding is attempted.

Seed in accordance with the following schedule and application rates:

Seeding Dates	Seeding Mixture Species and Application Rate
September 1 – February 15	50% Annual Ryegrass (<i>Lolium multi-florum</i>) at 60 lbs/acre and 50% Cereal (Winter) Rye (<i>Secale cereale</i>) at 50 lbs/acre
February 16 – April 30	Annual Ryegrass at 100 lbs/acre
May 1 – August 31	German Millet at 50 lbs/acre

- B. To amend soil, follow recommendations of soil tests or apply 4000 lbs/acre ground agricultural limestone and 600 lbs./acre 10-20-10 fertilizer.
- C. Mulch with three inch straw applied at the rate of 4000 lbs/acre, and anchor by tacking with netting or a mulch anchoring tool.
- D. Refertilize if growth is not fully adequate.
- E. Reseed, refertilize, and mulch immediately following erosion or other damage.

3.05 Permanent Seeding

- A. Seed in accordance with the following schedule and application rates:

Seeding Dates	Seeding Mixture Species and Rate
April – May 15 or August 16 – October (for slopes 3:1 or shallower)	Kentucky 31 Fescue at 128 lbs/acre Red Top Grass at 2 lbs/acre Annual Rye at 20 lbs/acre
April – May 15 or August 16 – October (for slopes 3:1 or steeper)*	Kentucky 31 Fescue at 108 lbs/acre Red Top Grass at 2 lbs/acre Common Bermudagrass at 20 lbs/acre <i>Sericea lespedeza</i> at 20 lbs/acres (hulled)
May 16 – August 15 (for slopes 3:1 or shallower)	Kentucky 31 Fescue at 128 lbs/acre Red Top Grass at 2 lbs/acre Foxtail Millet at 20 lbs/acre
May 16 – August 15 (for slopes 3:1 or steeper)*	Kentucky 31 Fescue at 108 lbs/acre Red Top Grass at 2 lbs/acre Foxtail Millet at 20 lbs/acre <i>Sericea lespedeza</i> at 20 lbs/acres (hulled)

- B. Apply lime and fertilizer according to soil tests, or apply 4,000 lbs/acre ground agricultural limestone and 1,000 lbs/acre 10-20-10 fertilizer.
- C. Mulch with three inch straw applied at the rate of 4000 lbs./acre. Anchor straw by tacking with netting, roving, or by crimping with a mulch anchoring tool.
- D. Refertilize in the second year unless growth is fully adequate. Reseed, refertilize, and mulch damaged areas immediately.

***** END OF SECTION *****

SECTION 330505

UNDERGROUND PIPE ABANDONMENT

PART 1 – GENERAL

1.01. Requirements Included

- A. Provide personnel, Materials and Equipment, and supplies to clean, cap and fill underground pipes with Controlled Low Strength Material (CLSM) such as lightweight cellular concrete, flowable fill, etc.
- B. Provide barricades, coverings, or other types of protection necessary to protect against damage to existing features and areas not to be disturbed.

1.02. Related Requirements

- A. Cast-in-place Concrete – Section 033000
- B. Earthwork – Section 310000

1.03. Submittals

- A. Submit description of proposed material for grouting, expected ultimate compressive strength (in pounds per square inch (psi)), method of controlling grout pressure, blocking, and bulkhead techniques.
- B. At least 15 Days prior to commencing grouting work, submit plan for grouting work describing the intended sequence of grouting, plugging, and anticipated grout volume.

PART 2 – PRODUCTS

2.01. Pipe Plugs

- A. Manufactured, commercially available pipe plug or cap specifically designed and manufactured to be used in pipe grouting service. Plug may be left in place permanently or removable after grout has achieved sufficient strength.
- B. Field constructed plugs must be of sufficient strength and liquid tightness to be used for the anticipated grouting pressures. Plug may be left in place permanently or removable after grout has achieved sufficient strength.

2.02. Controlled Low Strength Material (Flowable Fill)

- A. Unconfined compressive strength of grout material shall be greater than 30 psi and no more than 200 psi at 28 days.
- B. Material shall be non-shrink and self-leveling.

PART 3 – EXECUTION

3.01. Demolition

- A. Remove manholes, drop inlets, castings, etc. from areas not to receive grout fill. Manholes may remain during grouting process for pipe access; however, all but lowest section shall be removed once grouting is complete. Lowest section may be removed completely or left in place and grouted full with similar material.
- B. Structures removed shall be disposed of properly as directed by the Owner. Backfill voids with soil structural fill in accordance with Section 02200.
- C. Where adjacent pipes or manholes are not to be filled, place temporary plugs in each line or manhole to remain.

3.02. Preparation For Flowable Fill

- A. Submit material mix, proposed equipment, and grouting plan to OWNER and OWNER'S ENGINEER.
- B. Inspect pipes to be closed by closed circuit television to assess pipe condition, unidentified connections and to identify voids or obstructions. During placement of fill, compensate filling to account for obstructions or open areas to ensure no voids remain unfilled. Prepare an estimate of fill volume for each pipe segment.
- C. Clean pipes to remove excessive sediment, debris, and free water that may hinder fill placement.

3.03. Grouting Equipment

- A. Flowable fill mix shall be locally procured and delivered to the site in a concrete mixing truck or manufactured on site at time of use. Schedule deliveries or production so that the material does not sit past its workable stage without being used.
- B. Use pumps capable of delivering the grout material continuously at the planned farthest distance.

3.04. Installation Of Flowable Fill

- A. Place flowable fill between manholes or other planned access points not more than 500 feet apart.
- B. Flowable fill shall be placed by experienced crews with equipment to monitor fill volume and control grout pressure.
- C. Place flowable fill under pressure into properly vented pipes until grout emerges from the vent pipes. Pump flowable fill from the downstream end of the pipe system.

- D. Record the volume of flowable fill installed in each pipe section and compare with the anticipated fill volume. If the actual fill volume is less than 90% of the estimated volume, investigate to find locations of possible voids. Fill discovered voids by additional grouting.
- E. For existing structures left in place, remove upper sections of concrete structures and backfill remaining structure with similar grout material. Place and compact soil fill to existing grades per Section 02200.
- F. Collect and dispose of excess flowable fill materials, spillage, and other debris associated with the Work.

* * * * * END OF SECTION * * * * *

SECTION 330513

MANHOLES/DROP BOXES/VAULTS

PART 1 - GENERAL

1.01 Description Of Work

- A. CONTRACTOR shall furnish all Materials and Equipment, labor, tools, and appurtenances required to complete the precast concrete manholes, concrete valve boxes, and concrete vaults as described herein and/or shown on the Contract Drawings. CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all work.
- B. CONTRACTOR shall comply with all Laws and Codes.

1.02 Related Sections

- A. Concrete Formwork – Section 031000
- B. Concrete Reinforcement – Section 032000
- C. Cast-in-Place Concrete – Section 033000

1.03 Design Requirements

- A. Manholes/drop boxes/vaults shall be constructed of specified materials to the sizes, shapes, and dimensions and at the locations shown on the Contract Drawings or as otherwise directed by OWNER. The height or depth of manholes/drop boxes/vaults will vary with the location. The top and bottom elevations of manholes/drop boxes/vaults shall be as shown on the Contract Drawings.

1.04 Submittals

- A. CONTRACTOR shall submit to OWNER shop drawings and engineering data on frames, covers, grates, steps and precast manholes/drop boxes/vaults sections.
- B. CONTRACTOR shall submit to OWNER standard (typical) details showing joints and seals between precast manhole/drop box/vault riser sections and showing joints between pipes and manholes/drop box/vault walls.

1.05 Quality Assurance

- A. Prior to delivery, all basic materials specified herein shall be tested and inspected by an approved independent commercial testing laboratory or, if approved by OWNER, certified copies of test reports prepared by the manufacturer's testing laboratory will be acceptable. All materials which fail to conform to the requirements of the Contract, this Scope of Work, and these Specifications shall be rejected.

- B. After delivery to the Project Site, any Materials and Equipment or Construction Aids, which have been damaged in transit or are otherwise unsuitable for use in the Work shall be rejected and removed from the Project Site, at no additional cost to OWNER.

PART 2 - PRODUCTS

2.01 Materials And Construction

A. Concrete and Reinforcement

1. Concrete used in manhole, drop box, vault construction shall be 4,000 psi concrete conforming to the requirements of Section 033000 - Cast-In-Place Concrete of these Specifications.
2. Steel reinforcement shall be epoxy coated and conform to the requirements of Section 032000 - Concrete Reinforcement of this Scope of Work and these Specifications.

B. Precast Concrete Manholes:

1. Precast concrete manholes shall consist of precast reinforced concrete sections, a conical or flat slab top section, and a base slab section conforming to the typical manhole details as shown on the Contract Drawings.
2. Precast manhole sections shall be manufactured, tested, and marked in accordance with the latest provisions of ASTM C 478.
3. The minimum 28-day compressive strength of the concrete for all sections shall be 4,000 psi.
4. The maximum allowable absorption of the concrete shall not exceed eight percent of the dry weight.
5. The circumferential reinforcement in the riser sections, conical top sections and base wall sections shall consist of one line of steel and shall be not less than 0.17 square inch per lineal foot.
6. The ends of each reinforced concrete manhole riser section and the bottom end of the manhole top section shall be so formed that when the manhole risers and the top are assembled, they will make a continuous and uniform manhole.
7. Joints of the manhole sections shall be of the tongue and groove type. Sections shall be joined using O-ring rubber gaskets conforming to the applicable provisions of ASTM C443, latest revision, or filled with an approved preformed plastic gasket meeting the requirements of Federal Specifications SS-S-00210, "Sealing Compound, Preformed Plastic for Pipe Joints", Type 1, Rope Form.
8. Each section of the precast manhole shall have not more than two holes for the purpose of handling and laying. These holes shall be tapered and shall be plugged with rubber stoppers or mortar after installation.

9. Stainless steel manhole steps shall be installed in each section of the manhole in accordance with the details on the Contract Drawings.

C. Frames, Covers, Attachments, and Steps:

1. Frames and covers shall be cast iron conforming to the minimum requirements of Federal Specifications WW01-652 or to ASTM A 48 for Class 30 Gray Iron Castings. All castings shall be made accurately to the required dimensions, fully interchangeable, sound, smooth, clean, and free from blisters and/or other defects. Defective castings which have been plugged or otherwise treated shall not be used. All castings shall be thoroughly cleaned and painted or coated with a bituminous paint. Each casting shall have its actual weight in pounds stenciled or painted on it in white paint.
2. Manhole access hatches/doors shall be cast-in-place in concrete top unit and shall be of type and dimension indicated on the Contract Drawings.
3. Interior concrete anchors, embedment plates, and fall protection system connection eyes shall be stainless steel with stainless steel hardware.
4. The contact surfaces of all manhole covers and hatches and the corresponding supporting frames shall be machined to provide full perimeter contact.
5. Interior manhole steps shall be stainless steel or Epoxy coated, and conform to the applicable provisions of ASTM Standard Specification Serial Designation C478.

D. Precast Concrete Drop Boxes and Vaults:

1. Precast concrete drop boxes shall consist of precast reinforced concrete sections, flat slab top section, and a base slab section conforming to the typical drop box details as shown on the Contract Drawings.
2. Precast drop box sections shall be manufactured, tested, and marked in accordance with the latest provisions of ASTM C 478.
3. The minimum 28-day compressive strength of the concrete for all sections shall be 4,000 psi.
4. The maximum allowable absorption of the concrete shall not exceed eight percent of the dry weight.
5. The reinforcement in the wall sections, top section, and base section shall consist of one line of steel and shall not be less than 0.17 square inch per lineal foot.
6. Each section of the precast drop box shall have not more than two holes for the purpose of handling and laying. These holes shall be tapered and shall be plugged with rubber stoppers or mortar after installation.

7. Joints of the drop box sections, if any, shall be of the tongue and groove type. Sections shall be joined using O-ring rubber gaskets conforming to the applicable provisions of ASTM C443, latest revision, or filled with an approved preformed plastic gasket meeting the requirements of Federal Specifications SS-S-00210, "Sealing Compound", Preformed Plastic for Pipe Joints", Type 1, Rope Form.

PART 3 - EXECUTION

3.01 Placement Of Precast Concrete Manholes

- A. Prior to placing precast manholes, a minimum 9-inch-thick layer of coarse aggregate shall be placed as bedding. After approval of bedding by OWNER, manholes shall be placed and inverts/bottom elevations established and verified.
- B. After placing manhole base, inverts shall be constructed using 4,000 psi concrete in accordance with details on the Contract Drawings and inverts shall have the same cross section as the invert of the culverts which they connect. The manhole invert shall be carefully formed to the required size and grade by gradual and even changes in sections.
- C. After the base section has been set, and inverts formed, the precast manhole sections shall be placed thereon, care being exercised to form the incoming and outgoing pipes into the wall of the manhole at the required elevations.
- D. The top unit with cast-in-place access hatch/door for the manhole shall be set at the required elevation and properly anchored to the masonry. Where manholes are constructed in paved areas, the top surface of the frame and cover shall be tilted to conform to the exact slope, crown, and grade of the existing adjacent pavement.

3.02 Placement Of Precast Concrete Drop Boxes And Vaults

- A. Prior to placing precast concrete drop boxes and vaults, a minimum 9-inch-thick layer of coarse aggregate shall be placed as a level bedding for the drop box.
- B. After approval of bedding by OWNER, drop boxes and vaults shall be placed, and their inverts shall be established and verified.
- C. Covers, grates, hatches as indicated on the Contract Drawings shall be set at the required elevation and properly anchored to the drop box, as shown on the Contract Documents.

***** END OF SECTION *****

SECTION 400509

GEOMEMBRANE PIPE BOOTS AND SLEEVES

PART 1 GENERAL

1.01 Description

- A. Furnish and install HDPE pipe boot or pipe sleeve for use in areas where the geomembrane liner must be penetrated by drainage conveyance system as shown on plans and in accordance with these Specifications.

1.02 Quality Assurance

- A. The CONTRACTOR shall assist the OWNER and CQA Consultant in all testing required; the CONTRACTOR will supply any laborers and equipment necessary for assistance in the testing at no additional cost. This Work may include, but is not limited to providing material, samples and revising work to meet the intent of the plans and Specifications.

1.03 Submittals

- A. The CONTRACTOR shall supply material certificates for the boots, sleeves and stainless steel straps.
- B. If the boot or sleeve is fabricated by the manufacturer, shop drawings must be submitted for approval by the OWNER'S ENGINEER and OWNER. The boot or sleeve shall not be shipped until the shop drawings are approved.

1.04 Related Work

- A. HDPE Geomembrane – Section 310519.16

PART 2 - PRODUCTS

2.01 Pipe Boots And Pipe Sleeves

- A. The pipe boot or sleeve shall be constructed or manufactured with High Density Polyethylene (HDPE) to match other installed geomembrane.

PART 3 - EXECUTION

3.01 Construction Methods

- A. The pipe boot or sleeve shall be installed in areas where the geomembrane liner must be penetrated as shown on the Contract drawings.
- B. Prior to constructing the boot or sleeve, the CONTRACTOR shall assure that the material in the area of the penetration is properly compacted and that the area is clean. The CONTRACTOR shall take extreme care in work to assure the geomembrane liner is not damaged.

- C. The size of the boot or sleeve shall be adequate to provide 6" overlap of the geomembrane liner.
- D. Extrusion welding shall be as shown on the Contract drawings.
- E. When tightening the stainless steel adjustment bands, the CONTRACTOR shall be careful not to over tighten the bands, thereby causing damage to the boot or sleeve.

3.02 Inspection And Testing

- A. The CONTRACTOR shall employ non-destructive testing of all welds to the geomembrane liner. A vacuum box test or spark test will provide adequate testing.
- B. The CONTRACTOR is responsible for providing all necessary test equipment and shall conduct the test. The testing of welds shall be observed by the OWNER and CQA Consultant.

* * * * * END OF SECTION * * * * *