



Technical Specifications

Tailings Storage Facility and Waste Rock Dump

Grassy Mountain Mine

Malheur County, Oregon

Submitted to:

Calico Resources USA Corp.

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Submitted by:

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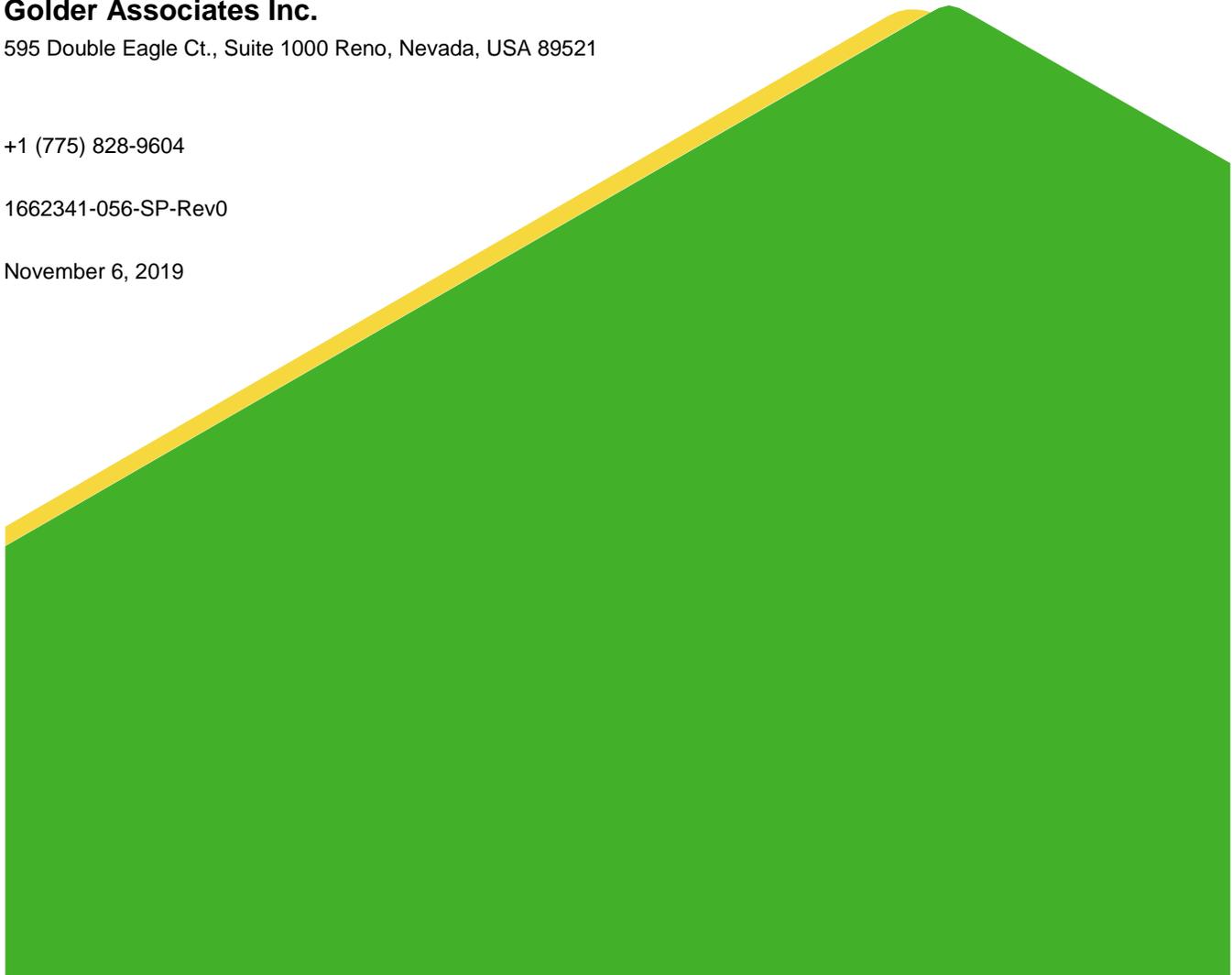


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**SECTION 01010
SUMMARY OF WORK**

1.0 GENERAL

1.1 Section Includes

- A. Work Scope
- B. Definitions
- C. Contradictions
- D. Contractor's Responsibilities

1.2 Work Scope

- A. The scope of work for this project shall consist of construction of Tailings Storage Facility (TSF) and Waste Rock Dump (WRD) at the Grassy Mountain Mine as shown on the Drawings. The Work under this contract will include, but is not limited to:
 - 1. Mobilization of all equipment and material required for the Work including: mobilization of temporary power facilities, sanitation facilities, and communication facilities.
 - 1. Installation of temporary and permanent surface water control.
 - 2. Furnishing and placement of construction water for both fill moisture control and dust control on roads and fills associated with construction of the Work in coordination with the Owner.
 - 3. Backfilling and compaction of exploration test pits and boreholes, as required by the Owner, within the TSF and WRD footprints.
 - 4. Clearing, grubbing, and stripping as required for the Work.
 - 5. Construction of temporary access and haul roads.
 - 6. Excavation, hauling, placement, of fill materials for the embankment, including Embankment Fill, Grading Fill, and Prepared Subgrade including moisture-conditioning and compaction.
 - 7. Excavation, hauling, processing, and placement of fill materials Drainage Layer, Filter Fill, Anchor Trench Backfill, Drain Gravel, Leak Detection Fill, Pipe Bedding Fill, and Cable Bedding Fill including moisture-conditioning and compaction.
 - 8. Subgrade preparation for geosynthetic clay liner (GCL) and high-density polyethylene (HDPE) geomembrane liner and embankment foundations.
 - 9. Furnishing and installing 60 and 80 mil HDPE Geomembrane liner in the areas shown on the Drawings.
 - 10. Furnishing and installing GCL.
 - 11. Furnishing and installing Non-woven Geotextile in areas shown on the Drawings.
 - 12. Furnishing and installing geonet in areas shown on the Drawings.
 - 13. Furnishing, welding, and installing corrugated polyethylene (CPE) and HDPE piping and filling.
 - 14. Demobilization, which includes: removal of temporary structures, shaping, contouring, and grading of final surfaces in preparation of reclamation seeding.

1.3 DEFINITIONS

- B. The following definitions apply to these Technical Specifications:
 - 1. "Owner" is defined as an authorized representative of Calico Resources USA Corp. (Calico).

2. "Engineer" is defined as a representative appointed and authorized by the Owner (Golder Associates, Inc.). The Engineer shall be a registered Professional Engineer in the State of Oregon, or a designated site representative under his supervision during construction.
3. "Resident Engineer" is defined as the Engineer's on-site representative to oversee the completion of Quality Assurance of the Work.
4. "Quality Control Team" is defined as the individuals working under the direction of Engineer to perform on-site Quality Control tasks at the frequencies listed in these Specifications. The Quality Control Team shall be approved by the Owner. All field and laboratory testing shall be supervised by a registered Professional Engineer licensed in the State of Oregon.
5. "Quality Assurance Team" is defined as the individuals working under the direction of Engineer to perform on-site quality assurance tasks for the Owner during earthwork placement, pipe installation, and geomembrane installation.
6. "Contractor" is defined as the party which has executed a contract agreement for the specified work with the Owner.
7. "Geomembrane Installation Contractor" is defined as the Subcontractor retained by the Contractor or the Owner to install the geomembrane, geotextile, geonet and related appurtenances.
8. "Vendor" is defined as the supply or manufacturer of fabricated materials retained by the Contractor or Owner required to complete the Work.
9. "Subcontractor" is defined as a party retained by the Contractor to provide services or materials required to complete the Work. The Subcontractor shall be under direct supervision and report directly to the Contractor.
10. "Quality Control" is defined as inspection and testing performed prior to manufactured material being placed as well as inspection and testing performed on earthwork materials placed during construction of the Work. Performed by the Contractor, Manufacturer, or facility retained by the Contractor or Manufacturer.
11. "Quality Assurance" is defined as inspection and testing performed by the Quality Assurance Team and third-party laboratories retained by the owner.
12. "Specifications" are defined as this document of Technical Specifications prepared by Golder Associates Inc. (Golder) for the Owner.
13. "Report" is defined as the Construction-level Design Report presented as Appendix C in the Grassy Mountain Consolidated Permit Application and titled *Detailed Design, Tailings Storage Facility and Waste Rock Dump, Grassy Mountain Mine, Malheur County, Oregon*, Revision 0, dated November 6, 2019 prepared by Golder in conjunction with these Specifications and Drawings.
14. "Drawings" are defined as the construction-level design drawings prepared by Golder in conjunction with these Specifications titled *Grassy Mountain Mine, Tailings Storage Facility and Waste Rock Dump*, Revision 0, dated November 6, 2019.
15. "Modifications" are defined as changes made to the Specifications or the Drawings that are approved by the Owner and Engineer in writing after the Specifications or the Drawings have been finalized.
16. "On-Site Material" is defined as borrow soils obtained from within required facility excavations.
17. "Off-Site Materials" is defined as material obtained from sources other than on-site.
18. "Record Documents" are defined as the documents prepared by the contractor documenting the progress, location, type and quantity of materials placed to complete the Work.
19. "Products" are defined as new material, machines, components, equipment, fixtures, and systems forming the Work. This does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work. Products may also include existing material or components required for reuse.

20. "Work is defined as the entire complete construction, or the various separately identifiable parts thereof, required to be furnished under the Contract Documents. Work is the result of performing services, furnishing labor, and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.
21. "Contract Documents" are defined as the Agreement, Addenda (which pertain to the Contract Documents), Contractor's Bid (including documentation accompanying the Bid and any post-Bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Agreement, the Bonds, the General Conditions, the Supplementary Conditions, the Specifications, the Drawings, the CQA Plan, together with all Modifications issued after the execution of the Agreement.
22. All slopes are described in terms of horizontal distance to vertical distance (H:V).

1.4 CONTRADICTIONS

- A. Should any contradiction, either implied or real, exist between the Specifications and the Drawings, the Contractor shall:
 1. Notify the Owner and Engineer.
 2. Stop all work that concerns the contradiction until the contradiction is remedied or clarified by the Engineer.
- B. The decision of the Engineer is final.

1.5 CONTRACTOR'S RESPONSIBILITIES

- A. The Contractor Shall:
 1. Maintain Oregon Workman's Compensation Insurance and provide evidence of such to the Owner.
 2. Familiarize himself/herself with the relevant regional and site-specific conditions which may have an impact upon the work.
 3. Be responsible for making his own measurements and installing his work to fit the conditions encountered.
 4. Before proceeding with the Work, examine all Drawings, Specifications, CQA Plan, and Reports and notify the Engineer and Owner in writing of any apparent discrepancies or interferences. The Engineer, in consultation with the Owner, shall make minor alterations to the Drawings as needed. All alterations shall be issued under a covering work order signed by the Owner prior to the start of alteration, if the alteration will affect the terms of Contract.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

END OF SECTION

**SECTION 01041
PROJECT COORDINATION**

1.0 GENERAL

1.1 Section Includes

- A. Contractor's Responsibilities
- B. Submittals

1.2 Related Sections

- A. Section 01010 – Summary of Work
- B. Section 01300 – Submittals
- C. Section 01500 – Reference Standards

1.3 Contractor's Responsibilities

- A. Cooperate with the Owner in allocation of mobilization areas, areas for field offices, access, traffic, and parking facilities.
- B. During construction, coordinate use of site and facilities through the Owner.
- C. Comply with Owner's and Engineer's procedures for intra-project communications
- D. Comply with instructions from the Owner for use of temporary utilities and construction facilities.
- E. Submit request for interpretation of the Contract Documents to the Owner, and obtain instructions through the Owner.
- F. All Contractor's personnel may be required to take site specific hazard training session, conducted by the Owner, and must have updated MSHA training in order to work at the site.

1.4 Submittals

- A. Submit Contractor's MSHA number to Owner.
- B. Submit MSHA health and safety certification of each employee that will work on site to the Owner prior to working at the site.
- C. Submit preliminary deployment drawings, show drawings, product data, and samples in accordance with Section 01300 for review and compliance with Contract Documents. Revise and resubmit as required.
- D. Maintain a record of man-hours worked on site and lost time accident hours. Submit the record weekly to the Owner.
- E. Submit copies of air quality permits, if such permits are required to construct the Work.
- F. Submit Material Safety Data Sheets (MSDS) to Owner for all chemicals or hazardous materials used on site, or stored on site, in support of performance of the Work. Submit weekly quantity use of TRI chemicals to the Owner, as requested by the Owner.
- G. Submit a disposal plan for all waste r contaminated materials developed on site during performance of the Work. Submit plan prior to mobilization.
- H. Submit statement at the end of the project stating that all waste and contaminated materials were disposed of in accordance with the approved plan.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

END OF SECTION

**SECTION 01042
MOBILIZATION**

1.0 GENERAL

1.1 Section Includes

- A. General

1.2 Work Scope

- A. Section 01010 – Summary of Work
- B. Section 01500 – Construction Facilities and Temporary Controls

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 General

- A. Upon receipt of notice to proceed, the Contractor shall furnish, mobilize and install such temporary works, materials, equipment, and construction plants as necessary for the successful completion of the Work. The Contractor shall also operate and maintain such temporary works, equipment and construction plants throughout the period of construction. All applicable temporary works, such as sanitation facilities, shall fully comply with the rules and regulations of the government agency having jurisdiction. Portable screening or crushing facilities used on-site shall have applicable air emissions permits. Clearing, grading, earthwork and construction of access roads necessary for the temporary works, if any, shall be included as mobilization.
- B. The Contractor shall obtain any permits necessary to complete the Work at Contractor's expense.

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

**SECTION 01050
FIELD ENGINEERING**

1.0 GENERAL

1.1 Section Includes

- A. Project Record Documents
- B. Examination
- C. Survey
- D. Alterations to Drawings and Specifications

1.2 Related Sections

- A. Section 01010 – Summary of Work
- B. Section 01090 – Reference Standards
- C. Section 01300 – Submittals

1.3 Project Record Documents

- A. The Contractor shall:
 - 1. Maintain a complete and accurate log of survey control and survey work.
 - 2. Make the log available for review to the Owner and Engineer without limitation.
- B. After project completion, submit record documents per Section 01300 – Submittals: As-built Documentation.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 General

- A. The Contractor shall notify the Owner and Engineer of any discrepancies discovered in the surveying or Drawings.

3.2 Survey

- A. The Owner shall provide a minimum of three (3) survey control points to layout and control the Work.
- B. The Contractor shall:
 - 1. Retain the services of a surveyor licensed in the State of Oregon.
 - 2. Use the survey control points provided by the Owner to lay out the Work.
 - 3. Triangulate between the three control-points to verify accuracy prior to using the points for control work.
 - 4. Perform a survey of the site in its original form on a minimum 100-foot grid. The survey will be submitted to the Engineer for review prior to initiation of growth media stripping. The survey will be used as a basis for quantity verification for site grading. If earthworks are performed prior to survey verification, Contract shall remedy at Contractor's expense.
 - 5. Survey the grid after completion of the following tasks and submit the topographic survey to the Owner and Engineer.
 - a. Growth Media Stripping.

- b. Excavation and placement of Embankment Fill.
 - c. Placement of Liner Bedding Fill (survey will be used to determine finish geomembrane liner limits and elevations).
 - d. Placement of Drainage Layer.
 - e. Placement of Filter Layer.
 - f. All permanent cut slopes or water diversion/control areas affected during construction.
6. Submit each survey to the Engineer within two (2) weeks of completion of each task.
 7. Provide additional surveying necessary to accurately maintain slopes and grades for control of the Work.
 8. The Contractor shall make every effort to preserve Owner-provided control and points. If, in the opinion of the Owner, any survey control points have been carelessly or willfully disturbed or destroyed by the Contractor or his employees, the cost of replacement shall be incurred by the Contractor.

3.3 Alterations To Drawings and Specifications

- A. Alterations made by the Contractor to either the Specifications or Drawings shall be subject to the Owner's and Engineer's approval and, where applicable, to the approval of regulatory agencies. All alterations shall be issued under a covering work order signed by the Owner prior to the start of alteration.

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

**SECTION 01051
GEOTECHNICAL EXPLORATION**

1.0 GENERAL

1.1 Section Includes

- A. Summary
- B. Verification
- C. Warranty

1.2 Summary

- A. Geotechnical explorations in the Tailings Storage Facility and Waste Rock Dump footprints were conducted during the following:
 - 1. December 2017 – 15 Borings, 44 Test Pits and six (6) field falling head permeability tests conducted in boreholes
 - 2. March 2019 – Six geotechnical boreholes at previously completed Test Pits
 - 3. July 2019 – 11 cone penetration test soundings at previously completed Borings and Test Pits
- B. The design for the Grassy Mountain TSF and WRD, written by Golder in November 2019 titled *Detailed Design, Tailings Storage Facility and Waste Rock Dump, Grassy Mountain Mine, Malheur County, Oregon*, Revision 0, dated November 2019 references the geotechnical investigation findings.
- C. Test Pit, Boring, and CPT exploration locations located within the TSF embankment, TSF basin, and WRD footprint will require over-excavation and backfill in accordance with Section 02222 and Section 02223.

1.3 Verification

- A. Field verify the location of all exploration boreholes and test pits with the Engineer and Owner.
- B. Contractor shall supply certification that all test pits have been filled in accordance with these Specifications. The Contractor will supply a list of the boreholes/pits backfilled with the certification, including the depth of each borehole/test pit.

1.4 Warranty

- A. The conclusions and recommendations described in the Golder Report cited above were based on Golder's understandings of the project, as described in the Report, and the site conditions as documented during Golder's geotechnical investigation. Unanticipated soil and subsurface conditions are commonly encountered and cannot be fully determined by reviewing soil logs from the borings or test pits. The report prepared by Golder should not be construed as a warranty of actual subsurface conditions.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Verification

- A. Bidders shall visit the site and familiarize themselves with all existing surface and subsurface conditions, whether covered in the reports or not, and shall understand all recommendations associated with the earthwork.

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

SECTION 01090
REFERENCE STANDARDS AND REGULATIONS

1.0 GENERAL

1.1 Section Includes

- A. Codes and Regulations
- B. Schedule of References

1.2 Related Sections

- A. Section 01400 – Quality Control/Assurance
- B. Section 01600 – Materials and Equipment
- C. Section 02110 – Site Clearing and Stripping
- D. Section 02205 – Fill Materials
- E. Section 02211 – Rough Grading
- F. Section 02223 – Filling
- G. Section 02273 – Geonet
- H. Section 02350 – Geosynthetic Clay Liner
- I. Section 02710 – Gravity Piping
- J. Section 02775 – Geomembrane
- K. Section 03300 – Cast-in-Place Concrete

1.3 Codes and Regulations

- A. The work shall conform to applicable federal, state, county, and local regulations.
- B. The following publications current at the date of Contract Documents, unless specified otherwise, are a part of this specification, except where modified or replaced by local codes or ordinances having jurisdiction, in which case such local codes or ordinances shall govern:
 - 1. Occupational Safety and Health Administration, General Industry and Health Standards – OSHA 2206.
 - 2. Mine Safety and Health Administration - Code of Federal Regulations - Title 30 (Mineral Resources)
 - 3. Oregon Department of Transportation.
 - 4. U.S. Department of Transportation.
 - 5. Clean Water Act – Oregon Department Environmental Quality.
 - 6. Environmental Impact Statement and the Plan of Operations at the site, if applicable.
 - 7. Water Resources Department (WRD), Dam Safety Regulations, OAR 690, Division 20.
 - 8. Department of Geology and Minerals Industries (DOGAMI), Chemical Process Mine Regulations, OAR 632, Division 37.
 - 9. Department of Fish and Wildlife (ODFW), Chemical Process Mining Consolidated Application and Permit Review Standards, OAR 635, Division 420.

10. Department of Environmental Quality (DEQ), Chemical Mining, OAR Chapter 340, Division 43.

1.4 Schedule of References

A. For products of workmanship specified by association, trade, or Federal Standards, all shall comply with the requirements of the standard, except when more rigid requirements are specified or are required by applicable codes. Conform to reference standard that is current at the date of Contract Documents. As a minimum the following reference standards shall be used for this project:

1. AASHTO American Association of State Highway and Transportation Officials
444 North Capitol Street, N.W.
Washington, DC 20001
2. ACI American Concrete Institute
Box 19150
Redford Station
Detroit, MI 48219
3. ANSI American National Standards Institute
1430 Broadway
New York, NY 10018
4. ASTM American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103
5. AWWA American Water Work Association
6666 West Quincy Avenue
Denver, CO 80235
6. CRSI Concrete Reinforcing Steel Institute
933 Plum Grove Road
Schaumburg, IL 60195
7. NSF National Sanitation Foundation
Box 1468
Ann Arbor, MI 48106
8. GRI Geosynthetics Research Institute
Drexel University
West Wing – Rush Building, #10
Philadelphia, PA 19104
9. NSF National Sanitation Foundation
Box 1468
Ann Arbor, MI 48106
10. PPI Plastic Pipe Institute
105 Decker Court, Suite 825
Irvine, TX 75062

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

END OF SECTION

SECTION 01300 SUBMITTALS

1.0 GENERAL

1.1 Section Includes

- A. Technical Data
- B. Progress Schedules
- C. As-Built Documentation

1.2 Related Sections

- A. Section 01400 – Quality Control/Assurance
- B. Section 01600 – Materials and Equipment
- C. Section 02205 – Fill Materials
- D. Section 02223 – Filling
- E. Section 02273 – Geonet
- F. Section 02350 – Geosynthetic Clay Liner
- G. Section 02710 – Gravity Piping
- H. Section 02775 – Geomembrane
- I. Section 03220 – Reinforcing Steel
- J. Section 03300 – Cast in Place Concrete

1.3 Technical Data

- A. Engineering data covering all equipment and fabricated materials to be furnished under this contract shall be submitted to the Engineer for review. This data shall include drawings and descriptive information in sufficient detail to show the kind, size, arrangement, and operation of component material and devices: the external connections, anchorages, and supports required; performance characteristics; and dimensions needed for installations and correlation with other materials and equipment. Data submitted shall include drawings showing essential details of any changes proposed by Contractor.
- B. No work shall be performed in connection with the fabrication or manufacture of material and equipment, nor shall any accessory or appurtenance be purchased until the drawings and data have been reviewed and approved by the Engineer, except at the Contractor's own risk and responsibility.
- C. Three (3) copies of each submittal, drawing, and necessary data shall be submitted to the Engineer. Each drawing or data sheet shall be clearly marked with the name of the project, the Contractor's name, references to applicable Specification paragraphs, and Drawing sheets. When catalog pages are submitted, the applicable items shall be identified. The Engineer shall return one (1) copy of the submittal to the Contractor with comments.
- D. When the drawings and data are returned marked REVISE AND RESUBMIT the corrections shall be made as noted thereon and as instructed the Engineer and not less than three (3) corrected copies resubmitted.

- E. When the drawings and data are returned marked REJECTED, the Contractor shall take necessary corrective actions to comply with contract documents. All items marked REJECTED will not be accepted and a substitute must be submitted for approval from the Engineer.
- F. Unless otherwise directed by the Engineer, when drawings and data are returned marked APPROVED AS NOTED, the changes shall be made as noted thereon and not less than three (3) corrected copies shall be furnished to the Engineer.
- G. When the drawings and data are returned marked APPROVED, one (1) copy, shall be returned to the Contractor, one (1) copy shall be retained for the Owner, and one (1) copy shall be retained by the Engineer.
- H. The Engineer's review of drawings and data submitted by the Contractor shall cover only general conformity to the Drawings and Specifications, external connections, and dimensions which affect the layout. The Engineer's review of drawings and data returned marked APPROVED or APPROVED AS NOTED does not indicate a thorough review of all dimensions, quantities, and details of the material, equipment, devices, or items shown, and does not relieve the Contractor from any responsibility for errors or deviations from the contract requirements.
- I. All drawings and data, after the final processing by the Engineer, shall become a part of the Contract Documents and the Work shown or described thereby shall be performed in conformity therewith unless authorized by the Owner or the Engineer.

1.4 Progress Schedules

- A. Procedure
 - 1. Submit a preliminary progress schedule to the Owner.
 - 2. After Owner's review, revise and resubmit schedule to comply with Owners review.
 - 3. Submit revised progress schedule every two weeks or according to a scheduled agreed upon by the Owner.
- B. Show complete sequence of construction by activity, with dates for beginning and completion of each element of construction.
- C. Provide subcontractors activity schedules.
- D. Provide separate schedule of submittal dates for shop drawings, product data, and samples, including Owner furnished products, and dates that reviewed submittals shall be required from the Owner and Engineer. Indicate delivery data for products.
- E. Schedules shall be in a form that is acceptable to the Owner.
- F. Distribute copies of reviewed schedules to the project file, Subcontractors, suppliers, and the Engineer.
- G. Instruct recipients to promptly report in writing problems anticipated by projections indicated in schedules.

1.5 Quality Control Test Results and Daily Field Reports

- A. The Contractor shall be responsible for material property testing of soil, rock, and aggregate material in accordance with the testing frequencies in Section 02223.
- B. Quality Control testing shall be performed by qualified personnel under direct supervision of a Professional Engineer licensed in the State of Oregon.
- C. Complete Quality Control Test results shall be submitted to the Owner and Engineer within twenty-four (24) hours of collecting sample for testing, or upon request, for review and approval.
- D. All Quality Control test results shall be stored in hard copy in the Contractor's or Quality Control's on-site facility and shall be available for review from the Owner and Engineer at all times.

- E. The Quality Control Team shall be responsible for accurately testing and reporting results of all Quality Control test results and observations in a timely manner to the Owner and Contractor throughout the project in the form of a Daily Field Report.
 - 1. Daily Field Reports shall be typed and submitted to the Engineer and/or Owner within one (1) working day.
 - 2. Minimum information required, and example Daily Field Report are presented in the CQA Plan

1.6 As-Built Documentation

- A. As-built Survey Documentation
 - 1. The Contractor shall be responsible for accurately surveying the locations and elevations and, where applicable, the type, thickness and geometry of any and all pipes and fittings, ditches, geosynthetic materials, breaks in fill or cut slopes, general grading, change in fill or synthetic material type and any other aspect of the work required by the Engineer.
 - 2. The Contractor shall submit as-built documentation surveys as described in Section 01050.
 - 3. Submittal: Completed as-built documentation will be submitted within two (2) weeks of project acceptance in the following manner:
 - a. Submit one (1) digital reproducible copy each to the Owner and Engineer.
 - b. Submit one (1) paper copy each to the Owner and Engineer.
 - i. As-built documentation survey shall be sealed by a registered Professional Land Surveyor licensed in the State of Oregon.
- B. Quality Control Documentation
 - 1. Submittal: Within two (2) weeks of project acceptance, the Quality Control Team shall submit a Quality Control Summary Report sealed by a Professional Engineer licensed in the State of Oregon documenting all manufacturer, field, and laboratory quality control test result and data sheets that include the following:
 - a. One (1) digital reproducible copy and one (1) paper copy of each of the following Quality Control Report(s):
 - i. Earthwork Quality Control Documentation in accordance with Section 02223.
 - ii. Geonet Quality Control Documentation in accordance with Section 02273.
 - iii. Geosynthetic Clay Liner Quality Control Documentation in accordance with Section 02350.
 - iv. Piping Quality Control Documentation in accordance with Section 02710
 - v. Geomembrane Quality Control Documentation in accordance with Section 02275.
 - vi. Reinforcing Steel Quality Control Documentation in accordance with Section 03220.
 - vii. Cast in Place Concrete Quality Control Documentation in accordance with Section 03300.

2.0 PRODUCTS NOT USED

3.0 EXECUTION NOT USED

END OF SECTION

SECTION 01400
QUALITY CONTROL AND ASSURANCE

1.0 GENERAL

1.1 Section Includes

- A. References
- B. General Quality Control Requirements
- C. Manufacturer's Quality Control Inspection, Sampling, and Testing
- D. Quality Control Sampling and Testing Frequency
- E. Quality Assurance and Referee Inspection and Testing

1.2 Related Sections

- A. Section 01090 – Reference Standards
- B. Section 01300 – Submittals
- C. Section 01410 – Testing Laboratory Services
- D. Section 01600 – Materials and Equipment
- E. Section 02205 – Fill Materials
- F. Section 02211 – Rough Grading
- G. Section 02223 – Filling
- H. Section 02273 – Geonet
- I. Section 02350 – Geosynthetic Clay Liner
- J. Section 02710 – Gravity Piping
- K. Section 02775 – Geomembrane
- L. Section 03300 – Cast-in-Place Concrete

1.3 References

- A. Conform to reference standard by date of issue current on date of Contract Documents unless specified otherwise in the specific section.
- B. Should specified reference standards conflict with Contract Documents, the Contractor shall request clarification from Engineer before proceeding.
- C. The contractual relationship of the parties to the Contract shall not be altered from the Contract Documents by mention or inference otherwise in any reference document.

1.4 General Quality Control Requirements

- A. The Quality Control Team as defined in Section 01010 shall perform the Quality Control testing and inspection required by these Specifications for all earthworks, geosynthetics, and piping installation.
- B. The Quality Control Team shall be under the direct supervision of a Professional Engineer licensed in the State of Oregon. All Quality Control test results shall be used as the record tests documented in the Quality Control As-built Report in accordance with Section 01300.

- C. Results of Quality test results are subject to verification by the Engineer. Should a discrepancy between results of the Quality Control Team and the Engineer, the Engineer's, results and conclusions shall prevail.
- D. Quality Control test results are not a basis of acceptance of Work. Results of inspection and testing on in-place material approved the Engineer or performed by the Quality Assurance Team shall prevail.
- E. The Contractor shall be responsible to monitor Quality Control over Vendors, Manufacturers, products, services, site conditions and workmanship to produce Work of specified quality.
- F. Comply fully with Manufacturers' instructions. Should Manufacturers' instructions conflict with the Contract Documents, the Contractor shall request clarification from the Engineer prior to proceeding.
- G. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes or specified requirements indicate higher standard or more precise workmanship.
- H. The Quality Control Team's inspections will not relieve the Contractor of responsibility for the acceptance of the finished Work or portions thereof.
- I. Work performed by the Quality Control Team personnel shall be qualified to perform specified testing in accordance with specified test methods and procedures as required by these Specifications.
- J. A summary report of the Quality Control Work performed shall be submitted to the Engineer in accordance with Section 01300 and be sealed by a Professional Engineer licensed in the State of Oregon.
- K. Re-testing required due to the Contractor's non-conformance to specified requirements of these Specifications shall be performed by the same Quality Control Team, Quality Assurance Team, or independent third party, as instructed by the Engineer. The cost of re-resting shall be borne by the Contractor if re-testing requires the testing agency to work extra hours or overtime.

1.5 Manufacturer's Quality Control Inspection, Sampling, and Testing

- A. The Manufacturer shall sample and perform Quality Control testing at the frequencies specified in these Specifications. Test results shall be submitted by the Contractor and/or the Manufacturer to the Engineer in accordance with Section 01300.
- B. The Manufacturer and/or Contractor will cooperate with the Quality Control Team; furnish samples of materials, design mixes, equipment, tools, storage, and assistance as required and:
 - 1. Notify the Engineer and Quality Control Team twenty-four (24) hours prior to expected time for operations requiring services.
 - 2. Make arrangements with Quality Control Team and pay for additional samples and tests required for Contractor's use.
- C. The Quality Control Team will submit to the Engineer one (1) copy of reports indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents in accordance with Section 01300.
 - 1. If observations, inspections, or Manufacture Quality Control test results identify any materials or methods used to complete the Work that do not meet these Specifications, the Engineer shall be notified immediately.

- 2. In the event that a test failed to meet these Specifications and a retest is performed, the Engineer shall be notified regardless of the retest results.
- 3. Removal of materials, repairs, or retests shall be determined by the Engineer. Costs associated with the Contractor's actions to remediate deficiencies shall be borne by the Contractor.

1.6 Quality Control Sampling and Testing Frequency

- A. The frequency of Contractor and Manufacturer Quality Control testing of materials is specified in the following sections:

Table 01400-1: Testing Frequency Reference Sections

MATERIAL	REFERENCE SECTION
Fill Materials	02205
Rough Grading	02211
Filling	02223
Geonet	02273
Geosynthetic Clay Liner	02350
Gravity Piping	02710
Geomembrane	02775
Cast-in-Place Concrete	03300

1.7 Quality Assurance and Referee Inspection and Testing

- A. The Quality Assurance Team as defined in Section 01010 shall perform the Quality Assurance testing and inspection required by these Specifications.
- B. At any time during the project Work, the Engineer may collect a sample split from the Quality Control sample and perform a referee test for Quality Assurance.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Quality Control

- A. Maintain access at all times for the Engineer and/or Quality Assurance Team to perform inspection, sampling, and testing. At no time deny the Quality Assurance Team personnel, Engineer, or Owner access to any Work area, fabrication area, staging area, or any other area associated with the Work.
- B. Make allowance for the Quality Assurance or referee sampling and testing to be performed and divert equipment elsewhere during the required sampling and testing.
- C. Quality Control test results shall be provided to the Owner and/or Engineer within 24 hours of collecting sample for testing, or upon request, for review and approval in accordance with Section 01300.

- D. Daily Field Reports shall be completed and submitted to the Engineer and/or Owner within one (1) working day in accordance with Section 01300. The minimum information required for each Daily Field Report as well as an example is provided in the CQA Plan.
- E. There is no provision for claims of delays due to Quality Assurance inspection, testing, or sampling. Should Contractor feel that delays are being incurred due to Quality Assurance inspection, testing, sampling, or other activities, notify Owner and Engineer in writing documenting in detail the date, time, and quality assurance activity of each occurrence. Should Owner and/or Engineer determine that excessive time is being spent at quality assurance activities causing delay to Work, corrective action will be taken.
- F. If any Work should be covered up without prior approval or consent of the Engineer, it must, if required by the Engineer, be uncovered for examination. After the uncovered Work has been observed and authorization given by the Engineer, the Work shall be recovered in accordance with the Specifications. The cost of uncovering and recovering the Work and any consequential costs shall be the responsibility of the Contractor regardless of the condition of the Work uncovered. If the Work is found to be deficient, the Contractor shall expose all Work that was covered prior to approval, correct any Work that is deficient, and proceed according to the Specifications. The cost of uncovering deficient Work, correcting deficient Work and any consequential costs shall be borne entirely by the Contractor.
- G. All Work performed by the Contractor shall meet the approval of the Engineer. The method and manner of doing the Work will be under the control of the Contractor. The Engineer may review the Contractor's work practices and make adjustments as necessary to minimize the risk of damage to critical components of the Work.

3.2 Submittals

- A. The Contractor shall submit all Quality Control test results to the Engineer for review and approval on a regular basis, or at the request of the Engineer.
- B. Fill materials proposed by the Contractor for use to complete the Work shall be tested by the Quality Control Team prior to placement to verify that the materials meets these Specifications.
- C. Initial Quality Control test results of proposed materials shall be submitted to the Engineer for the approval at least 24 hours prior to material placement.
- D. At the completion of the Work, a sealed Quality Control Report shall be submitted to the Owner and Engineer in accordance with Section 01300 and include at a minimum:
 - 1. Cover letter summarizing the quantities of materials placed, required testing frequency, and actual testing frequency achieved. The Quality Control Report shall be sealed by a Professional Engineer licensed in the State of Oregon.
 - 2. Typed field documentation including daily field reports, field and laboratory test results summary tables and individuals test results forms for all tests performed for each construction material for tests specified in the Specifications.
 - 3. Summary tables shall be suitable for report presentation and regulatory agency review. One (1) digital reproducible copy of the summary tables shall be provided to the Engineer.

END OF SECTION

**SECTION 01410
TESTING LABORATORY SERVICES**

1.0 GENERAL

1.1 Section Includes

- A. Selection and Payment
- B. Laboratory Reports
- C. Limits on Testing Laboratory Authority
- D. Contractor Responsibilities

1.2 Related Sections

- A. Section 01300 – Submittals
- B. Section 01400 – Quality Control/Assurance
- C. Section 01600 – Materials and Equipment
- D. Section 02205 – Fill Materials
- E. Section 02211 – Rough Grading
- F. Section 02223 – Filling
- G. Section 02273 – Geonet
- H. Section 02350 – Geosynthetic Clay Liner
- I. Section 02775 – Geomembrane
- J. Section 03300 – Cast-in-Place Concrete

1.3 Selection and Payment

- A. The Contractor shall perform, or will employ and pay for services of an independent testing laboratory to perform specified inspection and testing.
- B. All laboratory testing shall be performed under the direct supervision of a registered Professional Engineer licensed in the State of Oregon.
- C. Employment of testing laboratory shall in no way relieve the Contractor of obligation to perform work in accordance with requirements of Contract Documents.

1.4 Laboratory Reports

- A. After each inspection and test, promptly submit a copy of laboratory report to the Engineer, and a copy to the Owner.
- B. Include in Report:
 - 1. Date issued
 - 2. Project title and number
 - 3. Name of inspector
 - 4. Date and time of sampling or inspection
 - 5. Identification of product and Specifications Section

6. Location in the Project
7. Type of inspection or test
8. Date of test
9. Results of test
10. Conformance with Contract Documents
11. When requested by Engineer, provide interpretation of test results

1.5 Limits On Testing Laboratory Authority

- A. Laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.
- B. Laboratory may not approve or accept any portion of the Work.
- C. Laboratory may assume any duties of Contractor.
- D. Laboratory has no authority to stop Work.

1.6 Contractor Responsibilities

- A. The Contractor shall notify the laboratory and Engineer at least five (5) working days in advance of intended use of materials that require laboratory testing to allow sufficient time for laboratory to retrieve samples and perform testing.
- B. Provide proposed mix designs at least five (5) working days in advance of intended use.
- C. Cooperate with laboratory personnel, and provide access to the Work.
- D. Provide incidental labor and facilities to provide access to Work to be tested, to obtain and handle samples at the site or at source of products to be tested, to facilitate tests and inspections, storage and curing of test samples.
- E. When requested by the Engineer prior to sampling, the Contractor shall provide Engineer a split sample for Quality Assurance testing. The sample shall be split in accordance with ASTM C702-*Standard Practice for Reducing Samples of Aggregate to Testing Size*, and shall be of sufficient quantity to meet minimum testing requirements.
- F. Notify the laboratory and Engineer 24 hours prior to expected time for operations requiring field inspection and field testing services.
- G. Arrange with the laboratory and pay for additional testing and inspection services required by Contractor beyond specified requirements.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

END OF SECTION

SECTION 01500
CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

1.0 GENERAL

1.1 Section Includes

- A. Access
- B. Power
- C. Construction Water
- D. Fugitive Dust Control
- E. Surface Water Control
- F. Work Limits
- G. Traffic Control/Road Use

1.2 Related Sections

- A. Section 01010 – Summary of Work

1.3 Access

- A. Access to the site shall be provided by the Owner.
- B. The Contractor shall not construct any staging areas, temporary facilities, haul roads, or access roads without the approval of the Owner.

1.4 Power

- A. Contractor shall provide his own temporary power needs, unless provided by the Owner.

1.5 Construction Water

- A. Water for dust control on haul roads, moisture conditioning of borrow material to be placed as fill, and for maintaining in place fill soils shall be obtained by the Contractor. The Contractor shall supply all the pumps and tanks necessary to provide an adequate supply of water fulfill the conditions of the contract. Water will be available in a pond and/or truck standpipe at a location designated by the Owner.

1.6 Fugitive Dust Control

- A. During the performance of the Work defined by these Specifications or any operations appurtenant thereto, whether on right-of-way provided by the Owner or elsewhere, the Contractor shall:
 - 1. Furnish all labor, equipment, materials, and means required to perform proper and efficient measures to reduce the dust nuisance.
 - 2. Prevent dust which has originated from the Work from damaging land, vegetation, and dwellings or causing a nuisance to persons.
 - 3. Control dust to a degree acceptable to the appropriate State and Federal Agencies, and to the Owner.
 - 4. Notify Owner in writing, and obtain Owner's approval, to use chemical additives to control fugitive dust. Provide Material Safety Data Sheets (MSDA) for such chemicals to Owner.

1.7 Surface Water Control

- A. Install permanent ditches and/or channels shown on the drawings and construct facilities to control surface water resulting from precipitation.
- B. Provide temporary erosion protection for prepared surfaces and all potential erosion areas associated with the Work, or as directed by the Engineer, until all such portions of the Work have been accepted by the Owner. Erosion control shall consist of silt fences, fiber rolls, and sediment traps in accordance with best management practices.
- C. If precipitation or runoff damage occurs to the Work prior to acceptance of the Owner, repair the damaged Work in accordance to these Specifications at the Contractor's expense.
- D. All temporary and final design storm water diversion ditches, sedimentation basins, and/or channels shall be installed prior to site grading.

1.8 Work Limits

- A. Confine apparatus, equipment, the storage of Materials, and the operation of workmen to the limits indicated by law, ordinances, permits, or as directed by the Owner.
- B. Avoid unreasonable encumbering the premises with materials or equipment.
- C. Do not block plant or other access roads or traveled ways.
- D. Avoid interfering with the Owners operations.
- E. Do not present a hazard to the Owner's personnel and equipment or to the public.
- F. Use existing roads whenever possible.
- G. Minimize construction of new roads.
- H. Keep the site neat, tidy and free of waste materials or rubbish.
 - I. Store and dispense fuel, lubricating oils, and chemicals in such a manner as to prevent or contain spills and prevent said materials from reaching local streams or groundwater according to regulatory requirements.
- J. Dispose of waste in accordance with state and local regulations.
- K. Keep MSDS on file at the site and provide copies of such sheets to the Owner for all hazardous materials.
- L. Avoid damage to monitoring wells, piezometers, survey monuments, or any other instrumentation used at the site.
- M. Notify Owner if monitoring wells, piezometers, or instrumentation is in conflict with the Work prior to construction.

1.9 Traffic Control/Road Use

- A. Owner's mine haulage traffic has the right-of-way at all times. The Contractor shall conduct his haul operations in a safe manner yielding to Owner's haulage equipment and providing flagmen, if necessary, to stop Contractor's equipment at haul road crossings, public road crossings, or other

traffic areas. Flag persons will not be required at haul road crossings during water truck hauling. A stop sign will be installed at crossings to give the Owner's haulage equipment right-of-way.

- B. Any Public or private roads that become damaged as a result of the Contractor's hauling operations shall be repaired at the Contractor's expense.
- C. Contractor's personnel will park personal vehicles in areas designated by the Owner. The quantity and routes of normal construction or supervisory vehicles through the mine site will be agreed on by the Owner and Contractor.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

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

SECTION 01600
MATERIALS AND EQUIPMENT

1.0 GENERAL

1.1 Section Includes

- A. Transportation and Handling
- B. Storage and Protection
- C. Product Options
- D. Substitutions

1.2 Related Sections

- A. Section 01400 – Quality Assurance/Control

1.3 Transportation and Handling

- A. Transport and handle products in accordance with manufacturer's instructions.
- B. Promptly inspect shipments to assure that products comply with requirements, quantities are correct, and products are undamaged.
- C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.4 Storage and Protection

- A. Store and protect products in accordance with manufacturer's instructions, with seals and labels intact and legible. Store sensitive products in weather-tight, climate controlled enclosures.
- B. For exterior storage or fabricated products, place on sloped supports, above ground.
- C. Cover products subject to deterioration from ultraviolet light or weather with impervious sheet covering.
- D. Provide ventilation to avoid condensation.
- E. Store loose granular materials on solid flat surface in a well-drained area.
- F. Prohibit mixing with foreign matter.
- G. Arrange storage of products to permit access for inspection.
- H. Contractor shall inspect products to assure products are undamaged and maintained under specified conditions.
- I. At the end of construction, catalog all remaining unused permanent materials and provide catalog list to Owner, including description, quantity, and location. Store unused permanent materials in the location directed by the Owner. Except for soil and rock products, all permanent materials shall be stored on pallets or other methods to prevent ground contact. Containers holding permanent materials shall be protected against deterioration from rain and water.

1.5 Product Options

- A. Products Specified by Reference Standard or by Description Only: Any product meeting those standards or descriptions.
- B. Products Specified by Naming One or More Manufacturers. Products of manufacturers named and meeting Specifications, no options or substitutions allowed.
- C. Products Specified by Naming One or More Manufacturers with a provision for Substitutions: Submit a request for substitution for any manufacturer not named.

1.6 Substitutions

- A. Engineer will consider request for Substitutions only within 15 days after date established in Notice to Proceed.
- B. Substitutions may be considered when a products becomes unavailable through no fault of the Contractor.
- C. Substitution Submittal Procedure:
 - 1. Submit three (3) copies of Request for Substitution for Consideration. Limit each request to one proposed substitution.
 - 2. Submit shop drawings, product data, and certified test results attesting to the proposed product equivalence.
 - 3. The Engineer shall notify the Contractor, in writing, of decision to accept or reject request.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

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

**SECTION 01700
DEMBOLIZATION**

1.0 GENERAL

1.1 Section Includes

- A. General
- B. Warranty
- C. Summary

1.2 Related Sections

- A. Section 01010 – Summary of Work
- B. Section 01600 – Materials and Equipment

1.3 General

- A. The demobilization work consists of repairing all slopes disturbed during construction, the removal of all construction debris, and returning the site to a suitable condition for permanent stabilization and reclamation of disturbed surfaces as required by the Owner.

1.4 Warranty

- A. All materials and workmanship furnished by the Contractor under this specification shall be guaranteed by the Contractor against failure due to defective materials or improper installation for a period of one year from the date of final acceptance, or as noted otherwise in these Specifications. Upon receipt of written notice of failure of guaranteed workmanship or materials during the guarantee period, the Contractor shall promptly furnish and install new materials and/or furnish the labor necessary to correct the failure at the expense of the Contractor.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Summary

- A. Permanent cut slopes outside of the Work area that have been affected by the Work shall not have a slope steeper than 2.5H:1V unless otherwise shown in the Drawings or otherwise approved by the Owner and Engineer.
- B. The Contractor shall remove all trash, debris, hazardous and dangerous chemicals or waste, and waste material from the site that was brought on site by the contractor and properly dispose of all said materials. The Owner will have the right to determine what is waste or rubbish and the manner and place of disposal. All materials furnished for the execution of the Work and thereby purchased by the Owner shall remain the property of the Owner.
- C. The Contractor shall clean out all installations and tear down and remove all temporary structures built by the Contractor. Any existing structures or installations that were in place prior to construction shall be left in a condition at least as good as the condition prior to construction. All trash and remnants of the Contractor's work shall be removed by the Contractor prior to final inspection and acceptance by the Owner.

- D. Unused permanent materials shall be cataloged and stored in accordance with specification Section 01600.
- E. The final condition of the site is subject to approval by the Owner.

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

**SECTION 02110
SITE CLEARING AND STRIPPING**

1.0 GENERAL

1.1 Section Includes

- A. Clearing
- B. Stripping

1.2 Related Sections

- A. Section 02205 – Fill Materials
- B. Section 02211 – Rough Grading
- C. Section 02222 – Excavating
- D. Section 02223 – Filling

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Summary

- A. Clearing area required for access to site and execution of Work as shown on the Drawings.
- B. Remove shrubs and other vegetative growth within the required areas. Remove stumps and roots great than ½ inch in diameter to a minimum depth of 6 inches.
- C. Remove man-made structures, debris, or waste material as directed by the Owner/Engineer.
- D. All clearing shall be completed prior to the start of any grading operations.
- E. Clearing shall extend laterally beyond excavation, liner systems, and fill slopes a minimum of 10 feet but shall not extend past the Plan of Operations Boundary as designated by the Owner.
- F. Clearing shall not be performed until all exploration test pits and boreholes within the limits of the proposed site grading have been excavated and re-compacted in accordance with Sections 02222 and 02223 as approved by the Owner. The location of the test pits and boreholes are shown on the Drawings.

3.2 Stripping

- A. Growth media (the surficial soils often referred to as Topsoil) shall be stripped from cleared areas to a depth approved by the Engineer. In undisturbed areas, the typical stripping depth is anticipated to be 6-inches. The actual depth will be determined in the field by the Engineer during the stripping operation.
- B. Growth media shall be stockpiled in areas designated by the Owner. Construct stockpiles with maximum 3H:1V slopes and in a manner that the soil receive the maximum amount of compactive effort from the haulage equipment.
- C. Growth media stripping shall include removal of all organic sod, grass, topsoil and roots greater than ½ inch in diameter.

- D. Stripping shall be performed in the footprint of the TSF embankments and basin, reclaim pond, waste rock dump facility, containment channels, temporary and permanent access roads, haul roads, construction and staging areas, on-site borrow areas, and temporary and permanent diversion facilities.
- E. Stripping shall extend laterally beyond excavations, liner systems, and fill slopes a minimum of 10 feet but shall not extend past the Plan of Operations Boundary as designated by the Owner.
- F. Stripping shall not be performed until all exploration test pits and boreholes within the limits of the proposed site grading have been excavated and re-compacted in accordance with Sections 02222 and 02223 as approved by the Owner. The location of the test pits and boreholes are shown on the Drawings.
- G. All stripping shall be completed prior to the start of any grading.
- H. Excess stripping without the prior approval of the Owner will be at the expense of the Contractor.

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

**SECTION 02205
FILL MATERIALS**

1.0 GENERAL

1.1 Section Includes

- A. Definitions
- B. References
- C. General
- D. Embankment Fill
- E. Grading Fill
- F. Prepared Subgrade
- G. Drainage Layer
- H. Filter Fill
- I. Anchor Trench Backfill
- J. Drain Gravel
- K. Leak Detection Fill
- L. Pipe Bedding Fill
- M. Cable Bedding Fill
- N. Riprap
- O. Safety Berm Material

1.2 Related Sections

- A. Section 01051 –Geotechnical Exploration
- B. Section 01400 – Quality Control/Assurance
- C. Section 02110 – Site Clearing and Stripping
- D. Section 02211 – Rough Grading
- E. Section 02222 – Excavating
- F. Section 02223 – Filling

1.3 Definitions

- A. Embankment Fill: Fill material that is non-gold-bearing blasted run-of-mine rock or native alluvial overburden soils borrowed from on-site grading and quarry operations. Embankment Fill will be placed and compacted in controlled lifts and used as the primary fill material for TSF embankment construction in accordance with Section 02223.
- B. Grading Fill: Native alluvial soils excavated to be placed and compacted in controlled lifts below the geomembrane liner within the TSF basin and WRD pad.
- C. Drainage Layer: Crushed rock or screened native alluvium material placed above the geomembrane liner within the TSF basin to promote drainage into the perforated underdrain collection pipes.
- D. Filter Fill: Alluvial fill material placed above the Drainage Layer within the TSF basin to act as a filter between the Drainage Layer and the tailings and promote drainage into the perforated underdrain collection pipes.

- E. Anchor Trench Backfill: Soil or rock material placed and compacted in the geomembrane anchor trenches and placed as ballast on the above ground process conveyance pipes.
- F. Drain Gravel: Crushed rock material installed around the primary perforated CPE and HDPE underdrain collection pipes and in the reclaim pond leak detection sump.
- G. Leak Detection Fill: Crushed rock material placed around the PVC leak detection pipes below the TSF geomembrane liner to promote drainage into the perforated leak detection pipes.
- H. Riprap: Crushed and screened rock material placed in permanent diversion channels and outlet aprons for erosion protection.
- I. Safety Berm Material: native or processed material placed along travel to protect proposed structures from vehicle traffic.

1.4 References

- A. American Society for Testing and Materials (ASTM)
- B. ASTM C 702 – Standard Practice for Reducing Samples of Aggregate to Testing Size
- C. ASTM D 422 – Standard Test Method for Particle-Size Analysis of Soils
- D. ASTM D 1140 – Standard Test Method for Amount of Materials in Soils Finer than the No.200 (75 Micrometers)
- E. ASTM D 1556 – Test Method for Density of Soils in Place by the Sand-Cone Method
- F. ASTM D 1557 – Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
- G. ASTM D 2216 – Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
- H. ASTM D 4318 – Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- I. ASTM D 4643 – Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
- JJ. ASTM D 5519 - Standard Test Methods for Particle Size Analysis of Natural and Man-made Riprap Materials
- J. ASTM D 5856 – Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-wall, Compaction-mold Permeameter.
- K. ASTM D 6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-aggregate by Nuclear Methods (Shallow Depth)

2.0 PRODUCTS

2.1 General

- A. All fill materials shall be obtained from required excavations, designated borrow areas, and stockpiles as directed by the Owner. The selection, blending, routing, and disposition of materials in the various fills shall be subject to approval by the Engineer.
- B. Fill materials shall contain no sod, brush, roots or other perishable, unsuitable materials, debris, and the type of materials used as earth fill shall be as described in the Specifications and Drawings. The suitability of all fill materials intended for use in the Work shall be subject to approval by the Engineer.

2.2 Embankment Fill

- A. Embankment Fill shall be material that is non-gold-bearing blasted run-of-mine rock from on-going mining operations or the basalt borrow.

- B. If Embankment Fill contains greater than 30% of particles in excess of three-quarter inch (3/4") nominal grain size it shall be considered a rock fill and placed accordingly as described in Specification 02223.
- C. Embankment Fill shall meet the following gradational and plasticity requirement and shall be placed and compacted in accordance with Section 02223:

Table 1: 02205-1 Embankment Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
16 inch*	100
12 inch*	50-100
8 inch*	30-100
¾ inch	0-80
No. 4	0-40
No. 200	0-20

Plastic Limit: N/A

- D. A maximum of any one (1) sieve size is allowed to be out of the specified range list above for any individual test.
- E. * Maximum particle size shall be limited to 2/3 the allowable loose lift height based on the Embankment Fill being classified as a Soil or Rock Fill material. Allowable loose lift thickness shall determined in accordance with Section 02223.

2.3 Grading Fill

- A. Native alluvial materials excavated during on-site grading operation within the TSF basin and WRD pad or imported native alluvial materials.
- B. Native foundation clay materials, as defined by the Engineer, shall not be used as Grading Fill.
- C. If Grading Fill contains greater than 30% of particles in excess of three-quarter inch (3/4") nominal grain size it shall be considered a rock fill and placed accordingly as described in Specification 02223.

Table 2: 02205-2 Grading Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
6 inch	100
¾ inch	20-100
No. 4	10-70
No. 40	0-40
No. 200	0-30

Plastic Limit: Less than or equal to 15

2.4 Prepared Subgrade

- A. Native material generated from on-site grading operations or developed from on-site borrow area to be placed immediately below the geosynthetic clay liner within the TSF basin, WRD Pad, on the TSF upstream embankment slopes, and below the reclaim pond.
- B. Prepared Subgrade shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

2. Table 3: 02205-3 Prepared Subgrade Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
3 inch	100
¾ inch	70-100
No. 4	20-100
No. 40	0-60
No. 200	0-50

Plastic Limit: Less than or equal to 20

2.5 Drainage Layer

- A. Crushed rock material or processed native alluvium placed above the geomembrane liner within the TSF basin and WRD Pad to promote drainage into the perforated underdrain collection pipes.
- B. Drainage Layer shall have a maximum hydraulic conductivity of 5×10^{-3} cm/sec (ASTM D5856).
- C. The Drainage Layer shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 4: 02205-4 Drainage Layer Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
3 inch	100
¾ inch	50-100
No. 4	20-50
No. 40	0-25
No. 200	0-15

Plastic Limit: Less than or equal to 10

2.6 Filter Fill

- A. Crushed rock material, processed or native alluvium placed above the Drainage Layer within the TSF basin to act as a filter between the Drainage Layer and the tailings and promote drainage into the perforated underdrain collection pipes.
- B. Filter Fill shall have a maximum hydraulic conductivity of 5×10^{-4} cm/sec (ASTM D5856).

- C. Filter Fill shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 5: 02205-5 Filter Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
1.5 inch	100
¾ inch	30-90
No. 4	55-85
No. 40	25-50
No. 200	10-30

Plastic Limit: Less than or equal to 10

2.7 Anchor Trench Backfill

- A. Anchor Trench Backfill shall be on-site native alluvium placed in geomembrane anchor trenches and placed as ballast on the Tailings Distribution and Decant Return pipes in accordance with the Drawings.
- B. Anchor Trench Backfill shall be placed in accordance with Section 02223.
- C. Anchor Trench Backfill has no gradational or plasticity requirements.

2.8 Drain Gravel

- A. Drain Gravel shall be a manufactured, crushed rock installed around the primary underdrain collection pipes, within the underdrain outlet channel, and the reclaim pond leak detection sump.
- B. Drain Gravel shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 6: 02205-6 Drain Gravel Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
2 inch	100
¾ inch	50-80
No. 4	15-50
No. 200	0-5

Plastic Limit: Less than or equal to 10

2.9 Leak Detection Fill

- A. Crushed rock material installed around the leak detection pipes in accordance with the drawings to promoted drainage into the perforated leak detection pipes.
- B. The Leak Detection Fill shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 7: 02205-7 Leak Detection Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
1 inch	100
¾ inch	75-100
½ inch	20-55
No. 200	0-10

Plastic Limit: Less than or equal to 5

2.10 Pipe Bedding Fill

- A. Pipe Bedding Fill shall be on-site native alluvium placed as backfill around culverts and buried HDPE Piping in locations as shown on the Drawings.
- B. Pipe Bedding Fill shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 8: 02205-8 Drainage Layer Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
2 inch	100
¾ inch	70-100
No. 4	20-70
No. 40	0-35
No. 200	0-25

Plastic Limit: Less than or equal to 20

2.11 Cable Bedding Fill

- A. Cable Bedding Sand shall be placed as backfill around instrumentation signal cables in locations as shown on the Drawings.
- B. Cable Bedding Fill shall be the finer fraction of on-site native alluvium or Drainage Layer processed over the ¾-inch screen and placed in accordance with Section 02223.

2.12 Riprap

- A. Riprap shall be a process rock material placed as erosion protection as the finish surface layer on the side slope and toe diversion channel as shown on the Drawings.
- B. Riprap shall consist of a competent rock material with a specific gravity greater than 2.65 and a rock strength of R4 or greater in accordance with ISRM and from an on-site borrow area or raveling from exposed rock cut slopes near the Work area.
- C. Riprap shall meet the following gradational and plasticity requirements and be placed in accordance with Section 02223.

Table 9: 02205-8 Drainage Layer Gradation

Rip Rap D ₅₀	Rock Gradation	Rock Size (in.)
8"	D ₁₀₀	12
	D ₈₅	10
	D ₅₀	8
	D ₁₅	3
12"	D ₁₀₀	18
	D ₈₅	14
	D ₅₀	12
	D ₁₅	4
16"	D ₁₀₀	24
	D ₈₅	20
	D ₅₀	16
	D ₁₅	6
28"	D ₁₀₀	42
	D ₈₅	36
	D ₅₀	28
	D ₁₅	12

2.13 Safety Berm Material

- A. Safety Berm Material shall be on-site native alluvium placed along the edges of access and haul roads as needed for vehicle and structure protection.
- B. Safety Berm Material has no gradational or plasticity requirements.

2.14 Source Quality Control

- A. Quality Control inspection and testing will be performed under provisions of Sections 01010, 01400, and 01410 under the supervision of a professional engineer licensed in the State of Oregon.
- B. Frequency of testing will be in accordance with Section 02223.
- C. Quality Control tests and analysis of soil materials will be in accordance with ASTM D 422, ASTM D 1557, ASTM D 4318 and ASTM D 2167, and D 6938.
- D. If tests indicate materials do not meet specified requirements, changes in material or placement conditions, retests shall be performed by the Quality Control Team at no cost to Owner.

3.0 EXECUTION

3.1 Stockpiling

- A. If stockpiling is performed, materials shall be stockpiled at locations designated by the Owner. Stockpile sufficient material to meet project schedule and requirements. Separate different materials to prevent mixing. Direct Surface water away from stockpile to prevent erosion or deterioration of material.
- B. Leave unused stockpile material in a neat, compact stockpile.
- C. Prevent mixing of native subgrade soils with stockpile material.
- D. Refer to Section 02223 for fill placement requirements.

3.2 Borrow Area Cleanup

- E. Leave area in a clean and neat condition. Grade site surface to prevent free standing surface water. Grade slopes to a maximum 2.5H:1V slope.

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

**SECTION 02211
ROUGH GRADING**

1.0 GENERAL

1.1 Section Includes

- A. References
- B. Lines and Grades
- C. Subgrade Preparation
- D. Site Grading
- E. Field Quality Assurance

1.2 Related Sections

- A. Section 01051 – Geotechnical Exploration
- B. Section 01400 – Quality Control/Assurance
- C. Section 01410 – Testing Laboratory Services
- D. Section 02110 – Site Clearing and Stripping
- E. Section 02205 – Fill Materials
- F. Section 02222 – Excavating
- G. Section 02223 – Filling

1.3 References

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM D 422 – Standard Test Method for Particle-Size Analysis of Soils
 - 2. ASTM D 1556 – Test Method for Density of Soils in Place by the Sand-Cone Method
 - 3. ASTM D 1557 – Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
 - 4. ASTM D 2216 – Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
 - 5. ASTM D 4318 – Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
 - 6. ASTM D 4643 – Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
 - 7. ASTM D 6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Lines and Grades

- A. Locate control points and verify that the vertical and horizontal positioning are as indicated on the Drawings.

- B. Stake required lines, levels, contours, and datum.
- C. Protect Owner-supplied control points from excavation equipment and vehicular traffic.
- D. Replacement of destroyed or lost Owner-supplied control points shall be at the expense of the Contractor.
- E. As required in Section 01050, prior to commencement of grading within Work area, and after completion of site stripping activities, the Contractor shall provide a detailed survey of the stripped ground surface of the Owner. The survey shall have an accuracy of plus or minus 0.2 feet with a 2 foot contour interval. The survey will be used by the Owner and Engineer to confirm that the general grading requirement provided in these Specifications are met and to detail areas where additional site grading may be required.

3.2 Subgrade Preparation

- A. Remove all stockpiles, roadway fills, and any other undocumented fills prior to subgrade preparation.
- B. *Under Embankment Foundation and Grading Fill:* Proof-roll subgrade under the footprint of the dam embankment with a loaded scrapper, a loaded water truck, or a loaded haul truck to identify soft spots in the presence of the Engineer. Remove soft or yielding subgrade soils identified by the proof-roll to the depth determined by the Engineer. Fill these areas in accordance with Section 02223. Prior to placement of the Embankment Fill material, scarify the subgrade to a minimum depth of 12 inches, moisture condition to near optimum moisture content, and compact the subgrade to a minimum of 90 percent of the soils maximum dry density as determined by ASTM D 1557, or as approved by the Engineer. Roughen the final surface with at least two (2) passes of sheepsfoot compactor, wedge foot compactor, or other equipment approved by the Engineer.
- C. *In Areas within the TSF Basin to Receive Geomembrane where Grading Fill is Required:* Proof-roll subgrade under the Grading Fill with a loaded scrapper, a loaded water truck, or a loaded haul truck to identify soft spots in the presence of the Engineer. Remove soft or yielding subgrade soils identified by the proof-roll to the depth determined by the Engineer. Fill these areas in accordance with Section 02223. Prior to placement of the Grading Fill material, scarify the subgrade to a minimum depth of 12 inches, moisture condition to near optimum moisture content, and compact the subgrade to a minimum of 90 percent of the soils maximum dry density as determined by ASTM D 1557, or as approved by the Engineer. Roughen the final surface with at least two (2) passes of sheepsfoot compactor, wedge foot compactor, or other equipment approved by the Engineer.
- D. *In Areas within the TSF Basin to Receive Geomembrane on Native or Excavated Ground:* Following compaction, the upper surface of Prepared Subgrade shall be graded and oversized rock greater than 1-inch diameter, and projections shall be removed from the exposed surface. Prior to geosynthetics placement, the final surface of the Prepared Subgrade shall be proof-rolled with a minimum of 4 passes with vibratory smooth drum roller with a 10-ton static and 25 ton dynamic drum weight. The final surface shall be free draining, compact, free of protrusions, and suitable for geosynthetics placement
- E. If prior placed or prepared, tested, and accepted Prepared Subgrade or fills become loosened, softened, or disturbed by construction equipment traffic, during dry or wet weather, these materials shall be moisture-conditioned or dried, and recompacted. If weather or soil conditions prevent soils

from being properly compacted, the unsuitable soils shall be removed and replaced with properly compacted fill at no expense to the Owner.

3.3 Site Grading

- A. Grading Fill may be required to fill depressions or other areas identified by the Engineer. This material shall be placed according to Specifications 02223.
- B. Where fill is required in areas that are inaccessible using conventional compaction equipment, these area shall be compacted using hand-held equipment or backfilled using Lean Mix Concrete with the approval of the Engineer.

3.4 Field Quality Control

- A. Field Quality Control inspections and testing shall be performed in accordance with Sections 01010, 01400 and 01410. The Quality Control Team shall be under the supervision of a Professional Engineer licensed in the State of Oregon.
- B. In place density testing shall be performed in accordance with ASTM D 1556 or D 6938.
- C. Laboratory compaction testing to determine the soils maximum dry density shall be performed in accordance with ASTM D 1557.
- D. Frequency of tests: Field and laboratory testing of the Prepared Subgrade shall be performed in accordance with Section 02223.

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

SECTION 02222 EXCAVATING

1.0 GENERAL

1.1 Section Includes

- A. Lines and Grades
- B. Excavation
- C. Tolerances
- D. Quality Assurance

1.2 Related Sections

- A. Section 01051 – Geotechnical Explorations
- B. Section 01400 – Quality Control/Assurance
- C. Section 01500 – Construction Facilities and Temporary Controls
- D. Section 02110 – Site Clearing and Stripping
- E. Section 02211 – Rough Grading
- F. Section 02205 – Fill Materials
- G. Section 02223 – Filling

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Lines and Grades

- A. Locate control points and verify that the vertical and horizontal positioning are as indicated on the Drawings.
- B. Stake required lines, levels, contours, and datum.
- C. Protect Owner-supplied control points from excavation equipment and vehicular traffic.
- D. Replacement of destroyed or lost Owner-supplied control points shall be at the expense of the Contractor.
- E. As required in Section 01050, prior to commencement of grading within Work area, and after completion of site stripping activities, the Contractor shall provide a detailed survey of the stripped ground surface of the Owner. The survey shall have an accuracy of plus or minus 0.2 feet with a 2-foot contour interval. The survey will be used by the Owner and Engineer to confirm that the general grading requirement provided in these Specifications are met and to detail areas where additional site grading may be required.

3.2 Excavation

- A. Contractor shall excavate all loose and disturbed soil from exploration borings and test pits within the TSF, WRD, and reclaim pond footprints, as shown on the Drawings and presented in Section 01051 and backfill in accordance with Section 02223. Excavation and backfill borings and test pits shall be performed prior to site clearing and stripping.
- B. Excavate soils and rock to the lines and slopes shown on the Drawings.
- C. On-site materials encountered in excavations are anticipated to be alluvial soils, residual soils, and waste material.
- D. Grade the top perimeter of excavations to prevent surface water from draining into the excavation.
- E. Alluvial soils excavated on-site may be used for fill in the dam, subject to the specifications described in Section 02205 and Section 02223.
- F. All final cut surfaces will be moisture-conditioned and compacted in accordance with Section 02211 prior to subsequent fill placement.
- G. Remove loose, soft, and yielding material from the bottom and sides of excavations at the direction of the Engineer.
- H. During excavating operations, underlying foundation clays materials may be exposed. Contractor shall protect excavations from surface water run-on. In the event that foundation clay materials become saturated, or deemed unacceptable by the engineer, the Contractor shall overexcavate unsuitable materials and backfill the excavation with General Fill in accordance with Section 02223.
- I. Excavation extending beyond the lines, grades, and dimensions shown on the Drawings shall be backfilled with Grading Fill in accordance with Section 02223 at no expense to the Owner.
- J. Excavations shall be graded and properly maintained to provide adequate drainage at all times. Ponding shall not be allowed to develop. In excavation that cannot be properly graded to drain, such as ponds, the Contractor will provide equipment and labor to keep the excavation free of standing water.
- K. Excavation shall be suspended when the site is wet, muddy or in any other condition where the area cannot be properly maintained.
- L. Correct areas over-excavated in accordance with Section 02223.
- M. Stockpiles excess excavated material as directed by the Owner.
- N. The Contractor shall lay out diversion ditches and channels, so channels are excavated in original site soils and not fill. Ditches shall be laid out to provide minimum grades of 1 percent, unless shown flatter on the Drawings. Channel grade breaks shall not exceed 2 percent, unless otherwise shown on the Drawings.

3.3 Tolerances

- A. Local slopes shall be within 5 percent of those shown on the Drawings. Overall slopes will be within 0.1 percent of those shown on the Drawings.
- B. Finished grades shown on the Drawings are given in feet and tenths or hundredths of feet and shall slope uniformly between given spot and contour elevations. All grades shall provide for natural runoff of water without low spots or pockets.

- C. All excavations shall not exceed 0.3 feet in variation from dimensions and elevations shown on the Drawings, unless authorized by the Engineer.
- D. Minimum grades and slopes shown on the Drawings to provide drainage control shall be maintained.
- E. Correction of over-excavated and backfilling past the tolerances identified above shall be to the Contractor's account, at no expense to the Owner.

3.4 Quality Control

- A. Field Quality Control inspection and testing will be performed in accordance with Sections 01400 and 01410.
- B. Visual inspection of the excavated surface will be made to verify that all loose material has been removed or compacted and that there are no soft and yielding areas.
- C. In place density testing will be performed in accordance with Sections 02211 and 02223.

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

SECTION 02223
FILLING

1.0 GENERAL

1.1 Section Includes

- JJ. Related Sections
- KK. References
- LL. Fill Materials
- MM. Verification
- NN. Subgrade Preparation
- OO. Fill Placement
- PP. Tolerances
- QQ. Protection of Finished Work
- RR. Quality Control
- SS. Submittals
- TT. Quality Assurance

1.2 Related Sections

- A. Section 01051 – Geotechnical Explorations
- B. Section 01300 – Submittals
- C. Section 01400 – Quality Control/Assurance
- D. Section 01500 – Construction Facilities and Temporary Controls
- E. Section 02205 – Fill Materials
- F. Section 02222 – Excavating
- G. Section 02273 – Geonet
- H. Section 02350 – Geosynthetic Clay Liner
- I. Section 02775 – Geomembranes
- J. Section 02710 – Gravity Piping
- K. Section 03300 – Cast-in-Place Concrete

1.3 References

- A. ASTM D 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregate.
- B. ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils
- C. ASTM D 1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method
- D. ASTM D 1557 - Standard Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
- E. ASTM D 2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
- F. ASTM D 2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
- G. ASTM D 4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

- H. ASTM D 4643 – Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
- I. ASTM D 5519 – Standard Test Methods for Particle Size Analysis of Natural and Man-made Riprap Materials
- J. ASTM D 5856 – Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter
- K. ASTM D 6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.0 PRODUCTS

- A. Embankment Fill
- B. Grading Fill
- C. Drainage Layer
- D. Filter Fill
- E. Anchor Trench Backfill
- F. Drain Gravel
- G. Leak Detection Fill
- H. Riprap
- I. Safety Berm Material

3.0 EXECUTION

3.1 VERIFICATION

- A. Verify that lines and grades of fill limits and slopes have been established as required.
- B. Field verify location of all exploration boreholes and test pits with Engineer and Owner prior to site clearing and stripping.
- C. Contractor shall supply certification that all boreholes and test pits have been filled in accordance with these Specifications. The Contractor will supply a list of the boreholes/pits backfilled with the certification, including the depth of each borehole/pit.

3.2 SUBGRADE PREPARATION

- A. Prepare subgrade according to Section 02211 and Section 02222.
- B. Do not place fill until subgrade has been tested and approved by the Engineer.

3.3 FILL PLACEMENT

- A. Do not place frozen material as fill.
- B. Do not place fill on frozen ground. EXCEPTION: Fill may be placed on frozen subgrade provided that the depth of freezing is no more than 2 inches AND the subgrade has been previously tested and proof-rolled and approved by the Engineer. Engineer shall be consulted prior to fill placement when freezing depths are greater than 2 inches. Fill placement on frozen subgrade shall only be performed with the approval of the Engineer.
- C. Prior to topsoil stripping, boreholes and test pits within the TSF, WRD, and reclaim pond footprints shall be re-excavated to their original depths in accordance with Section 02222. All loose soils and debris shall be removed. The re-excavated explorations shall be backfilled with General Fill, placed in 12-inch maximum loose lifts, moisture-conditioned, compacted with tampers, vibratory compactors, hoe-packs, or other suitable approved compaction methods, to achieve a stable, non-yielding surface. Open boreholes shall be backfilled with bentonite seal in accordance with regulatory requirements.

- D. Fill materials shall be obtained from designated borrow areas or areas designated by the Engineer and Owner. For fill materials that are proposed to be imported by the Contractor from areas other than those designated by the Engineer, the Contractor shall give the Owner at least five (5) working days' notice prior to using the imported material to enable the Owner's representative to sample and test the material. Imported material must be tested for compliance with the Specifications and the results approved by the Engineer prior to the material being delivered to the site.
- E. Placement of fill shall be made only in areas approved by the Engineer for fill placement. Fill shall be placed to the lines and grades shown on the Drawings and according with these Specifications.
- F. Fill placement shall be temporarily stopped due to inclement weather conditions at the direction of the Engineer. Under marginal weather conditions, the Contractor may place fill, provided the fill, when tested, meets these Specifications.
- G. The distribution of materials shall be such that the fill is free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. The combined borrow excavation and fill placement operation shall be such that the materials, when compacted in the fill, will be blended sufficiently to provide the best practicable distribution of the material, subject to the approval of the Engineer.
- H. If, in the opinion of the Engineer, the surface of the subgrade or the surface of any layer of the fill is too dry or too smooth to bond properly with the layer of material to be placed thereon, it shall be scarified to a depth of 6 inches, or as directed by the Engineer, then moisture-conditioned to provide a satisfactory bonding surface before the next layer of fill material is placed.
- I. If, in the opinion of the Engineer, the surface of the subgrade or the rolled surface of any layer of the fill in place is too wet for proper compaction of the layer of fill material to be placed thereon, it shall be removed and allowed to dry or shall be worked with discs, scarifier, or other equipment to reduce the moisture content to the required amount, and then compacted before the next layer of fill material is placed.
- J. The Contractor shall place fill only after the subgrade below fills has been adequately compacted and approved by the Engineer. Should any of the work be covered before it has been approved, the Contractor shall uncover all such work at no cost to the Owner. After the work has been examined, tested and approved by the Engineer, the Contractor shall make all repairs and replacements necessary to restore the work to the contract specifications at no additional cost to the Owner.
- K. All fill materials shall be moisture-conditioned prior to applying compactive effort. Moisture-conditioning may be performed to fill material either in the borrow area or at the fill site or in both areas as directed by the Engineer. The Owner may also require additional moisture conditioning in the cut or fill to limit fugitive dust.
- L. During compaction operations, the borrow and reworked in-place materials requiring moisture conditioning shall be maintained within the range of moisture content required in these Specifications to achieve, with the equipment being used, adequate compaction to the specified density. The moisture content of the fill material prior to and during compaction shall be uniform throughout the material.
- M. When material is too dry for proper compaction and/or is below the minimum moisture content specified, the Contractor shall spray water on the fill and work the moisture into the fill by discing or scarifying, or other means approved by the Engineer, until a uniform distribution of moisture is obtained.
- N. Material that is too wet for proper compaction and/or is above the maximum moisture content specified, shall be removed from the fill or the material may be spread and permitted to dry, assisted by discing or scarifying until the moisture content is reduced to an amount suitable for obtaining the specified degree of compaction. The Contractor shall not mix underlying fill materials with fill materials being moisture conditioned.
- O. The upper 1-foot of final travel way surfaces shall not contain oversize materials greater than 3 inches.
- P. For purposes of these Specifications, soil fills are defined as a material where greater than 70% (by weight) passes the ¾-inch screen and rock fills are defined as materials where greater than 30% (by weight) is retained on the ¾-inch screen.

- Q. The relative compaction of fill materials shall be tested in-place to check compliance with the Specifications. Rock fills shall be compacted using compactive efforts and performance-based specifications as herein specified, or by an Engineer's approved method based on test fills with specific roller equipment. For the purposes of these specifications, relative compaction of soil fill is the ratio of the in-place dry density of the constructed fill to the maximum laboratory dry density determined by ASTM D 1557 (Modified Proctor).
- R. The Engineer shall continuously evaluate the Contractor's equipment and methods. If such equipment or methods are found unsatisfactory for the intended use, the Engineer will require the Contractor to replace the unsatisfactory equipment with other types or adjust methods until proper compaction is achieved.
- S. The Contractor shall maintain and protect fills in a condition satisfactory to the Engineer at all times until the final completion and acceptance of the work. Any approved fill material which becomes unsuitable for any reason whatsoever, after being placed in the fill and before final acceptance of the Work, shall be removed and replaced by the Contractor in a manner satisfactory to the Engineer.
- T. The Contractor shall route equipment and take all actions necessary to prevent material of one type from being deposited inadvertently, either by dumping or through travel of equipment, in or on material of another type. Such improperly deposited material shall be removed from the fill areas, as directed by the Engineer. If in-place material becomes contaminated, it shall also be removed. All removed material shall be wasted in locations designated by the Engineer. Removal of all such material shall be at no cost to the Owner.
- U. At no time shall the native foundation clay be used as General Fill or Embankment Fill. Any foundation clay that becomes exposed during rough grading operations, it shall be over excavated and backfilled, or capped with a minimum 12 inches of General Fill to the lines and grades shown on the Drawings at the direction of the owner.
- V. If prior placed, tested and accepted in-place fills become loosened, softened, or disturbed by construction equipment traffic, during dry or wet weather, these materials shall be moisture-conditioned or dried as previously described and recompacted. If weather or soil conditions prevent soils from being properly compacted, the unsuitable soils shall be removed and replaced with properly compacted fill. Such replacement and/or re-compaction shall be at no expense to the Owner.
- W. Berms and fills placed for diversion ditches shall be placed, compacted, and tested in accordance with these Specifications. When backfilling staged diversion ditches, fill shall be placed, compacted, and tested in accordance with these Specifications.
- X. Embankment Fill:
1. Areas to receive Embankment Fill shall include, but are not limited to: embankment, diversion ditches, access and perimeter roads, and diversion berms.
 2. Condition to a moisture content which allows compaction to the required density without an excessive amount of effort and that results in a stable non-yielding surface.
 3. Prior to subsequent staged Embankment Fill placement, the dam crest shall be scarified to a depth of 6 inches, or as directed by the Engineer, then moisture-conditioned prior to placement of the first lift of new Embankment Fill. The first lift placed over the scarified dam crest shall be placed to a maximum loose lift thickness of 12 inches to 18 inches, or less as required by these Specifications.
 4. Embankment Fill with less than 30 percent rock materials above 3/4-inch size and 8-inch maximum rock size (Embankment Soil Fill) shall be placed in 12-inch maximum loose lifts and compacted to 92 percent of maximum dry density (ASTM D1557).
 5. Embankment Fill containing more than 30 percent rock materials above 3/4-inch size (Compacted Rockfill) shall be placed as a rock fill and compacted according to the following method. However, in all cases vibratory drum compactors, if used as the primary means of compaction, must have a minimum 10-ton static and 25-ton dynamic drum weight.

6. For Rock Fills, a test fill shall be conducted to determine the maximum lift thickness and compactive effort for the material. The test fill may be located so that it is incorporated within the limits of the compacted fill area. The test fill shall be constructed and monitored as per U.S. Army Corps of Engineers' guidelines for test fill construction. The Contractor shall outline his proposed procedures for moisture conditioning and fill placement of Compacted Rock Fill and submit them to the Engineer for review and approval prior to placing the test fill.
7. Loose lift thicknesses of 12, 18, and 24 inches or as determined by the Engineer shall be used for the Test Fill; (three test fills to determine optimum lift thickness)
8. The data to be collected during construction of the test fill shall include:
 - a. Amount of settlement after every two passes of the proposed compaction equipment to a maximum of ten (10) passes;
 - b. Gradation and moisture content of in-place material; and
 - c. In-place fill density at completion of the test by bulk density or Nuclear Gauge methods.
 - d. A curve showing change in settlement versus number of passes shall be produced from the data. This curve will be used to determine the number of passes for acceptable compaction. In general, the minimum number of passes will be that number required to achieve 80 percent of the total settlement obtained after ten complete passes of the compaction equipment. Final determination by the Engineer of the lift thickness and minimum required passes will be based on a review of the test data.
 - e. Maximum rock size for rock fills shall be two-thirds of the compacted lift thickness, unless otherwise approved by the Engineer. Provisions shall be made by the Contractor for removal of oversize materials from fills for use as riprap or exterior slope protection. No additional payment will be made to remove oversize materials.

Y. Grading Fill

1. Areas to receive General Fill shall include, but are not limited to: TSF basin, perimeter access roads, reclaim pond, underdrain channel, WRD pad, and permanent diversion channels.
2. It is the intent of the design to use excavated materials within the TSF basin footprint as much as possible for General Fill.
3. Condition the fill to a moisture content which allows compaction to the required density without an excessive amount of effort and that results in a stable non-yielding surface.
4. Soil General Fill:
 - a. General Fill with less than 30 percent rock materials above 3/4-inch in size and 8-inch maximum rock size shall be placed in 12-inch maximum loose lifts and compacted to 92 percent of maximum dry density (ASTM D 1557).
5. Rock General Fill:
 - a. General Fill containing more than 30 percent rock materials above 3/4-inch size (Compacted Rockfill) shall be placed as a rockfill based on the results of a Test Fill as described in the Embankment Fill Section below. The type of compaction equipment, number of passes, lift thickness, and maximum rock size shall be approved by the Engineer in writing based on the acceptable Test Fill performance.
 - b. Maximum rock size for rock fills shall be two-thirds of the compacted lift thickness, unless otherwise approved by the Engineer. Provisions shall be made by the Contractor for removal of oversize materials from fills for use as riprap or exterior slope protection. No additional payment will be made to remove oversize materials.
6. The Contractor shall adopt methods to remove all oversize rock from the fill. Oversize rock will be stockpiled in a location designated by the Owner. No additional payment shall be made to the Contractor for oversize rock removal.

7. Where bedrock is encountered within 12 inches of the bottom of Prepared Subgrade, the Contractor shall place a 12-inch thick lift of soil General Fill as a "Rock Cap".

Z. Prepared Subgrade

1. Condition Prepared Subgrade to a moisture content which allows compaction to the required density without an excessive amount of effort and that results in a stable non-yielding surface.
2. Prepared Subgrade shall be placed in 12-inch maximum loose lifts and compacted to 92 percent of maximum dry density (ASTM D1557).
3. Following compaction, the upper surface of the Prepared Subgrade shall be treated as described in Section 02211 of these Specifications in preparation of geomembrane liner placement.
4. On slopes steeper than 20 percent, Prepared Subgrade shall be placed in 18-inch lifts be as measured perpendicular to the slope. Prepared Subgrade may be placed in a single 6-inch lift if the underlying Embankment Fill material is free from excessive coarse material, cobbles, and boulders. Reduction of the total lift thickness shall be approved by the Engineer.

AA. Drainage Layer

1. Drainage Layer shall not be placed until final inspection and approval of the geosynthetics has been made by the Engineer
2. Drainage Layer shall be placed over the geomembrane liner in one lift to result in a minimum eighteen (18)-inch-thick layer after construction is complete.
3. Drainage Layer shall not be compacted.
4. Drainage Layer shall have an in-place hydraulic conductivity of 5×10^{-3} cm/sec when tested in accordance with ASTM D 5856.
5. Drainage Layer shall be placed by dumping with trucks or loaders at the edge of geomembrane cover and spreading over the geomembrane with a dozer equipped with Low Ground Pressure (LGP) tracks that exert a pressure of seven (7.0) psi or less, or similar equipment, as approved by the Engineer, that will prevent heavy loads on the liner. Equipment shall not be allowed to come in direct contact with the plastic liner. Rubber-tire equipment shall not be allowed to cross over collection and distribution pipe at any time unless it can be proved by a field test that the subject equipment will not crush the pipe. It may be necessary to place a thicker lift of Drainage Fill over piping if an alternate method of placement is used. Alternative methods of placement proposed by the Contractor will be considered. However, such methods shall be proposed to and approved by the Engineer prior to mobilization of equipment to the site. The Engineer reserves the right to accept or reject any such alternative placement proposal.
6. Thickness of the Drainage Layer will be monitored by the Contractor with twenty-four (24)-inch-high highway cones, or an alternative method proposed by the Contractor and approved by the Engineer.
7. Hauling equipment shall operate on a minimum thickness of Drainage Layer Material above any geosynthetic layer as determined by the Engineer. Prior to commencing Work, Contractor shall provide a list of proposed equipment to operate on the Drainage Layer for approval and minimum roadway thickness determination.
8. In locations with the TSF basin and WRD pad where heat seaming has been used to join geomembrane sections, the protective cover material shall be spread in the same direction as the seam overlap to avoid placing additional stress on the seam.
9. The finished surface of the Drainage Layer shall be bladed with the LGP dozer to provide a surface free of ridges, mounds, and ponding areas.
10. The Contractor shall protect underlying geosynthetics from mechanical damage at all times during placement of Drainage Layer.

11. The geomembrane Installation Contractor shall take steps to minimize wrinkle generation in underlying geosynthetic materials during placement of the Drainage Layer. The measures may include placing protective layer material in the early morning hours when the geosynthetic materials are cool and monitoring and walking out wrinkles in the geosynthetic materials that appear at the edge of the placement area.
 12. Placement of Drainage Layer shall not be performed when the ambient air temperature exceeds 100°F or if excessive wrinkles developed in the geomembrane as determined by the Engineer.
- BB. The Contractor shall survey to control overall protective cover and drainage layer thickness as specified in Section 01050. Results shall be provided to the Engineer.
- CC. Filter Fill
1. Filter Fill shall be placed in a single 6-inch loose lift above the Drainage Layer and under riprap in the permanent diversion channels.
 2. Filter Fill shall not be compacted above the drainage layer.
 3. Filter Fill shall be compacted to a smooth and non-yielding surface where used as bedding below riprap.
 4. Filter Fill shall be placed by dumping with trucks or loaders and spreading over the Drainage Layer with a dozer equipped with Low Ground Pressure (LGP) tracks that exert a pressure of seven (7.0) psi or less, or similar equipment, as approved by the Engineer, that will prevent heavy loads on the liner. Rubber-tire equipment shall not be allowed to cross over collection and distribution pipe at any time unless it can be proved by a field test that the subject equipment will not crush the pipe. Alternative methods of placement proposed by the Contractor will be considered. However, such methods shall be proposed to and approved by the Engineer prior to mobilization of equipment to the site. The Engineer reserves the right to accept or reject any such alternative placement proposal.
 5. Thickness of the Filter Fill will be monitored by the Contractor with twenty-four (24)-inch-high highway cones, or an alternative method proposed by the Contractor and approved by the Engineer.
 6. Hauling equipment shall operate on a minimum thickness of Drainage Layer Material above any geosynthetic layer as determined by the Engineer. Prior to commencing Work, Contractor shall provide a list of proposed equipment to operate on the Drainage Layer for approval and minimum roadway thickness determination.
 7. The finished surface of the Filter Fill shall be bladed with the LGP dozer to provide a surface free of ridges, mounds, and ponding areas.
- DD. The Contractor shall survey to control overall protective cover and Filter Fill thickness as specified in Section 01050. Results shall be provided to the Engineer
- EE. Anchor Trench Backfill
1. Anchor Trench Backfill shall be placed in geomembrane anchor trenches.
 2. Fill placed in geomembrane anchor trenches shall be placed in maximum 12-inch thick compacted horizontal lifts and compacted by tamping with a minimum of two passes with a mechanical "whacker" type tamper or bucket compacted.
 3. Anchor Trench Backfill may be used as pipe ballast as directed by the Owner.
- FF. Drain Gravel
1. Drain Gravel shall be placed around the primary perforated CPE and HDPE underdrain collection pipes.
 2. Drain Gravel shall be placed around the pipe with a minimum clearance of 6-inches on all sides then wrapped with a non-woven geotextile.

3. No equipment other than track-mounted vehicle shall be allowed on the Drain Gravel.

GG. Leak Detection Fill

1. Leak Detection Fill shall be placed around the perforated PVC leak detection pipes.
2. Leak Detection Fill shall be around the pipe with a minimum clearance of 8-inches above and on the sides of the pipe.
3. Leak Detection Fill and leak detection pipe shall be placed directly above the GCL within the leak detection channel as shown on the Drawings.
4. No equipment other than track-mounted vehicle shall be allowed on the Leak Detection Fill.

HH. Pipe Bedding Fill

1. Pipe bedding fill shall be placed around leak detection risers, culverts and buried HDPE piping as shown on the Drawings.
2. Pipe Bedding Fill shall be brought up in horizontal lifts to prevent unbalanced pressure on structures or pipes.
3. Pipe Bedding Fill shall be placed a minimum of 6 inches below the pipe and shall be compacted and approved by the Engineer prior to pipe placement.
4. Pipe Bedding Fill shall be worked under pipe haunches by hand to provide uniform support of the pipe.
5. Pipe Bedding Fill shall be placed in maximum 6-inch loose lift, moisture-conditioned, and compacted to 92 percent of maximum dry density (ASTM D1557).
6. Only hand-guided mechanical tampers or hand-guided vibratory rollers shall be used for compaction around, over, near, or adjacent to pipes.

II. Cable Bedding Fill

1. Cable Bedding Fill shall be placed below and around instrumentation signal cables as shown on the Drawings.
2. Cable Bedding Fill shall be placed in a minimum 6 inches compacted lift below the signal cables and compacted to a smooth and non-yielding surface using hand-guided compaction equipment.
3. Cable Bedding Fill shall be placed in a single 12-inch loose above the signal cables and compacted with hand-guided compaction equipment to achieve a smooth and non-yielding surface.
4. Cable Bedding Fill shall extend a minimum of 12 inches on either side of the maximum extents of the signal cable layout.

JJ. Riprap

1. Riprap shall be placed above Filter Fill in permanent diversion channel and outlet aprons to the lines and grades shown on the Drawings.
2. Riprap shall be placed in a single lift equivalent to 1.5 times D_{50} .
3. Riprap shall be track walked or bucket compacted.

KK. Safety Berm Material

1. Safety Berm Material shall be placed along light vehicle and haul roads.
2. Safety Berm Material shall be uncompacted and placed by either front end loader, dozer, or motor grader.
3. Safety Berm Material shall be placed to such a height as to be equal to the middle of the axle of the largest vehicle assigned to the Work Area.

3.4 TOLERANCES

- A. Local slopes shall be within 5 percent of those shown on the Drawings, and overall slopes shall be within 0.1 percent of those shown on the Drawings.
- B. Finished grades shown on the Drawings are given in feet and tenths or hundredths of feet, and shall slope uniformly between given spot and contour elevations. All grades shall provide for natural runoff of water without low spots or pockets.
- C. Fill and backfill shall be placed within a tolerance of plus or minus 0.2 feet, unless otherwise approved by the Engineer. Where the thickness of fill or backfill is specified as a minimum thickness on the Drawings and/or in the Specifications, place fill to the minimum thickness shown. Layer thicknesses shown on the drawings are compacted thicknesses.
- D. Minimum grades and slopes shown on the Drawings provide drainage control and shall be maintained.
- E. Correction of over-excavation and backfilling beyond the tolerances identified above shall be to the Contractor's account, at no expense to the Owner.

3.5 PROTECTION OF FINISHED WORK

- A. Protect finished Work and Work in progress in accordance with of Section 01500.

3.6 QUALITY CONTROL

- A. Quality Control inspection and testing will be performed under provisions of Sections 01010, 01300, 01400, and 01410 under the supervision of a Professional Engineer licensed in the State of Oregon.
- B. In place density testing shall be performed in accordance with ASTM D 1556 or D 6938.
- C. Laboratory compaction testing to determine the soils maximum dry density shall be performed in accordance with ASTM D 1557.
- D. Laboratory permeability testing to determine hydraulic conductivity of the Drainage Layer shall be performed in accordance with ASTM D 5856.
- E. Field particle size analyses of riprap materials shall be performed in accordance with ASTM D 5519.
- F. If Quality Control test results indicate Work does not meet specified requirements, perform remedial action as described below.
 - 1. Immediately notify the Engineer.
 - 2. Compaction below specified minimum density:
 - a. Apply additional effort, or scarify, moisture condition, recompact, and retest.
 - 3. Moisture content outside of specified limits during compaction:
 - a. Moisture content below specified minimum: Scarify the depth of the lift, moisture condition, mix to achieve uniform moisture content, recompact, and retest.
 - b. Moisture content above specified maximum: Scarify the depth of the lift, allow to air dry, mix to achieve uniform moisture content, recompact, and retest or remove the wet material. Mixing of dry material to lower the moisture content will not be allowed without the prior approval of the Engineer and on a case by case basis.
 - 4. Moisture content outside of specified limits after compaction and approved prior to covering: Determine depth of material outside of specified limits and correct as specified above.
 - 5. Material not in accordance with material specification requirements of Section 02205: Remove material in its entirety as determined by the Engineer.
- G. Frequency of tests:

The following table shows the minimum frequency of Quality Control testing of soil, rock, and aggregate materials placed, unless otherwise approved by the Engineer:

Table 1: 02233-1 QUALITY CONTROL - MINIMUM TESTING FREQUENCIES

Material Type	Test	Number of Units Per Test					
		Field Density and Moisture	Field Particle Size Analysis	Laboratory Sieve Analysis	Laboratory Atterberg Limits	Laboratory Moisture Density Relationship	Laboratory Permeability
		D 6938	D 5519	D 422	D 4318	D 1557	D 5856
Subgrade	sq.ft	50,000	N/A	200,000	200,000	500,000	
Embankment Fill	cu.yds	2,000	N/A	5,000	5,000	20,000 per material type	
Grading Fill	cu.yds	1,000	N/A	5,000	5,000	20,000	
Prepared Subgrade	cu.yds	1,000	N/A	5,000	5,000	15,000	
Drainage Layer	cu.yds	N/A	N/A	5,000	5,000	N/A	2 per material type
Filter Fill	cu.yds	N/A	N/A	3,000	3,000	N/A	2 per material type
Anchor Trench Backfill	cu.yds	N/A	N/A	500	N/A	N/A	
Drain Gravel	cu.yds	N/A	N/A	200 (or 3 per material type)	200 (or 3 per material type)	N/A	
Leak Detection Fill	Each	N/A	N/A	2 per material type	2 per material type	N/A	
Pipe Bedding Fill	LF	100	N/A	100 (2 per material type)	100 (2 per material type)	200 (1 per material type)	
Cable Bedding Fill	cu.yds	N/A	N/A	2 per material type	2 per material type	N/A	
Riprap	cy.yds	N/A	2 per material type	N/A	N/A	N/A	
Safety Berm Material	cu.yds	N/A	N/A	N/A	N/A	N/A	

6. Tests may be conducted more or less frequently at the direction of the Engineer. More frequent testing shall be performed, where indicated by the following guidelines:
 - a. Areas where special compaction equipment or methods are used.
 - b. Areas where the height of fill rises quickly versus the quantity of fill placed.
 - c. Areas where doubtful construction procedures are being used.
 - d. Areas where the required compaction may not have been achieved based upon visual observations.
 - e. Areas where unacceptable material may have been placed.
7. If additional Quality Control testing is required by the Engineer, costs for additional testing shall be borne by the Contractor.
- H. Quality Control test results shall be made available to the Owner and Engineer within twenty-four (24) hours after completion of test.
- I. Quality Control test results shall be stored in hard copy in the Quality Control Team's on-site facility for from the Owner or Engineer at all times. If no hard copies are stored on-site, the Quality Control Team shall provide the electronic test results to the Engineer within twenty-four (24) hours after completion of the test.

3.7 Submittals

- A. The Quality Control test results shall be submitted to the Engineer for review and approval on a regular basis, or at the request of the Engineer.
- B. The Quality Control Team shall be responsible for accurately testing and reporting results of all Quality Control test results and observations in a timely manner to the Owner and Contractor throughout the project in the form of a Daily Field Report.
 1. Daily Field Reports shall be typed and submitted to the Engineer and/or Owner within one (1) working day.
- C. Fill materials proposed by the Contractor for use to complete the Work shall be tested by the Quality Control Team prior to placement to verify that the material meets these Specifications.
- D. Initial Quality Control test results of proposed materials shall be submitted to the Engineer for approval at least twenty-four (24) hours prior to material placement.
- E. At the completion of the Work, a sealed Quality Control Report shall be submitted to the Owner and Engineer in accordance with Section 01300 and include at a minimum:
 1. Cover letter summarizing the quantities of materials placed, required testing frequency, and actual testing frequency achieved. The Quality Control Report shall be sealed by a professional engineer licensed in the State of Oregon.
 2. Typed field documentation including daily field reports, field and laboratory test results summary tables and individual test results forms for all tests performed for each construction material for the tests specified in these Specifications.
 3. Summary tables shall be suitable for report presentation and regulatory agency review. One (1) digital reproducible copy of the summary tables shall be provided to the Engineer.

3.8 Quality Assurance

- A. The Quality Assurance Team shall perform Quality Assurance or Referee testing at the direction of the Engineer.
- B. The Engineer has the final decision regarding the use of a proposed material for completion of the Work.

- C. At any time, the Engineer or Quality Assurance Team may collect a sample split from the Quality Control Team's sample and perform a referee test for Quality Assurance.
 - 1. Quantity of tests and frequencies shall be at the discretion of the Engineer. Costs for Quality Assurance testing where test results do not meet these Specifications shall borne by the Contractor.

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

**SECTION 02272
GEOTEXTILE**

1.0 GENERAL

1.1 Section Includes

- A. References
- B. Performance Requirements
- C. Submittals
- D. Delivery, Storage, and Handling
- E. Material
- F. Deployment
- G. Seaming
- H. Quality Control
- I. Quality Assurance

1.2 Related Sections

- A. Section 01300 – Submittals
- B. Section 01400 – Quality Control/Assurance
- C. Section 01410 – Testing Laboratory Services
- D. Section 02205 – Fill Materials
- E. Section 02223 – Filling

1.3 References

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM D 4354 – Practice for Sampling of Geosynthetics for Testing
 - 2. ASTM D 4355 – Test Method for Deterioration of Geotextile from Exposure to Ultraviolet Light and Water
 - 3. ASTM D 4533 -Test Method for Trapezoidal Tearing Strength of Geotextiles
 - 4. ASTM D 4632 – Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
 - 5. ASTM D 4751 – Test Method for Determining Apparent Opening Size of a Geotextile
 - 6. ASTM D 4759 – Practice for Determining the Specification Conformance of Geosynthetics
 - 7. ASTM D 4873 – Guide for Identification, Storage and Handling of Geotextiles
 - 8. ASTM D 5035 – Test Method for Break Strength and Elongation of Textile Fabrics (2” Strip Method)
 - 9. ASTM D 5261 – Test Method for Determining Mass Per Unit Area
 - 10. ASTM D 6241 – Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50-mm Probe
 - 11. ASTM D 7238 – Test Method for Effect of Exposure of Unreinforced Polyfin Geomembrane Using Fluorescent Condensation Apparatus
- B. Geosynthetic Research Institute (GRI)
 - 1. GT12a – Test Method and Properties for Nonwoven Geotextile Used as Protection (or cushioning) Materials

1.4 Performance Requirements

- A. Contractor shall furnish and install the geotextile and all materials incidental to the installation in accordance with these Specifications.
- B. Alignment, lengths, and areas for geotextile placement are shown on the Drawings. Exact locations and lengths may be varied to suit conditions encountered in the field only as approved by the Engineer.
- A. Contractor shall furnish sufficient material to provide the finished geotextile shown on the Drawings; including material for all seams and laps. Contractor shall balance the actual project geotextile requirements, as determined by their quantity take-offs, against those shown on the Drawings.

1.5 Submittals

- A. Submittals detailed below shall be in accordance with Section 01300.
- B. After the Contract Award:
 - 1. Product Data: Provide manufacturer's data regarding filtration, permeability, and mechanical properties.
 - 2. Sample: Submit one (5 feet by 5 feet) sample with the machine direction marked.
- C. During Installation:
 - 1. Manufacturer Quality Control certificates

1.6 Delivery, Storage, and Handling

- D. Transportation: The geotextile shall be packaged and shipped in such a manner that the material is not damaged or exposed to damaging substances. Transportation shall be the responsibility of the Geomembrane Installation Contractor unless agreed to by the Manufacturer and the Owner, in writing, prior to the initiation of shipment of geotextile to the site.
- E. Off-Loading: Off-loading of the geotextile is the responsibility of the Geomembrane Installation Contractor. No off-loading of geotextile shall be performed unless the Owner's representative is present. Any damage to the rolls during off-loading shall be documented by the Owner's representative and the Geomembrane Installation Contractor. All damaged rolls must be stored separate from the undamaged rolls until. The rolls shall be unrolled to determine the extent of the damage. The use of the roll or portions of the roll shall be only at the approval of the Engineer. The cost of evaluating, replacing or repairing rolls damaged during off-loading shall be the sole responsibility of the Installation Contractor.
- F. Storage: The geotextile shall be stored according to manufacturer's recommendations, ASTM D 4873, and such that it is protected from puncture, dirt, grease, gasoline, diesel fuel, water, moisture, mud, mechanical abrasion, excessive heat and other causes of damage to the geotextile material.
- A. Rolls without the proper documentation shall be stored separately until all the required documentation is received and approved by the Engineer.

2.0 PRODUCTS

2.1 Material

- A. The geotextile as referenced in the Drawings and these Specifications shall be Non-woven Needle Punched Geotextile.
 - 1. Composition: Geotextile shall be of polypropylene or polyethylene fibers.
 - 2. Rolls shall be free of holes, contamination, and foreign matter.
- B. The geotextile supplied to the project shall meet or exceed the minimum (unless noted otherwise) roll values shown in the table below:

Table 02272-1: Minimum Average Roll Values For Geotextile Material (per GRI-GT12a)

Property ¹	ASTM Test Method	Value
Weight	D 5261	12 oz/sq.yd.
Grab Tensile	D 4632	300 lb
Grab Tensile Elongation	D 4632	50%
Trapezoidal Tear Strength	D 4533	115 lb
Puncture (CBR) Strength	D 6241	800 lb
UV Resistance (at 500 hrs)	D 7238	70% strength retained
Apparent Opening Size	D 4751	No. 100 Sieve (0.15 mm)

Notes:

1. Evaluation to be on a 2.0 inch strip tensile specimens per ASTM D 5035 after 500 light hour exposure.
- C. Rolls shall be manufactured a minimum of 15 feet wide and 300 feet long.
 - D. The geotextile will be warranted by the Manufacturer to be free from defects in materials and workmanship and to have a useful life of 5 years from the date of purchase under normal weathering and normal use.

3.0 EXECUTION AND DEPLOYMENT

3.1 Deployment

- A. Procedure and methods shall not damage the geotextile. Manufacturer's recommended deployment techniques shall be followed by the Contractor to the greatest extent possible.
- B. Do not deploy frozen geotextile.
- C. Do not deploy geotextile over frozen ground.
- D. Deploy only in areas approved by the Engineer.
- E. Placement of drainage aggregate should proceed immediately following placement of the geotextile. If a perforated collection pipe is to be installed, a bedding layer of drainage aggregate should be placed below the pipe, with the remainder of the aggregate placed to the minimum required construction depth.

3.2 Seaming

- A. Seams can be sewn or overlapped a minimum of 12 inches.

3.3 Quality Assurance

- A. Quality Assurance shall consist of:
 1. Review of required documentation.
 2. Approval of geotextile rolls for deployment.
 3. Observation of unrolled material for damage.
 4. Observation of seaming procedure and completed seams.
- B. Engineer has final authority in the Quality Assurance for the project.
- C. Compliance Testing:
 1. At the option of the Engineer, compliance testing may be performed at any time prior to, during, or after the installation.

2. The cost of the compliance testing shall be negotiated between the Owner and Contractor.
 3. The tests performed for the compliance testing shall be directed by the Engineer.
 4. Compliance testing shall not include any tests that are not listed in these Specifications as a basis for evaluating compliance of the geotextile to the Specifications.
 5. Sampling for Compliance Testing:
 - a. Samples shall be obtained by the Engineer.
 - b. The sample shall be taken as close to the middle of the roll as practical but shall, at a minimum, be sampled no closer than three (3) feet from the end of a roll.
 6. The sample shall be labeled by the Engineer, using a permanent marker, with the roll number, machine direction, date sampled, and name of individual that sampled the material.
- D. Seams:
1. Will be observed for required overlap and seaming procedures.
 2. Seams that do not have the required overlap will be marked for adjustment.

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

**SECTION 02273
GEONET**

1.0 GENERAL

1.1 Section Includes

- A. Definitions
- B. Performance Requirements
- C. Submittals
- D. Delivery, Storage, and Handling
- E. Material
- F. Deployment
- G. Seaming
- H. Quality Assurance

1.2 Related Sections

- A. Section 02775 – Geomembrane

1.3 References

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM D 792 – Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement
 - 2. ASTM D 1505 – Standard Test Method for Density of Plastic by the Density-Gradient Technique
 - 3. ASTM D 1603 – Test Method for Carbon Black in Olefin Plastics
 - 4. ASTM D 4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
 - 5. ASTM D 4354 – Practice for Sampling of Geosynthetics and Rolled Erosion Control (RECPs)
 - 6. ASTM D 4355 – Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
 - 7. ASTM D 4491 – Test Methods for Water Permeability of Geotextiles by Permittivity D 4533 Test Method for Trapezoidal Tearing Strength of Geotextiles
 - 8. ASTM D 4632 – Test Method for Grab Breaking Load and Elongation of Geotextiles
 - 9. ASTM D 4716 – Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic using a Constant Head
 - 10. ASTM D 4716 – Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
 - 11. ASTM D 4751 – Test Method for Determining Apparent Opening Size of a Geotextile
 - 12. ASTM D 4873 – Guide for Identification, Storage and Handling of Geosynthetic Rolls and Samples
 - 13. ASTM D 5035 – Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
 - 14. ASTM D 5199 – Standard Test Method for Measuring Nominal Thickness of Geotextile and Geomembranes
 - 15. D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles

16. ASTM D 6241 – Standard Test Method for Static Puncture Strengths of Geotextiles and Geotextile-Related Products Using a 50-mm Probe
 17. ASTM D 6364 – Standard Test Method for Determining Short-Term Compression Behavior of Geosynthetics
 18. ASTM D 7005 – Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposite
 19. ASTM D7179 – Standard Test Method for Determining Geonet Breaking Force
 20. ASTM D7238 – Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembranes Using Fluorescent UV Condensation Apparatus
- B. Geosynthetic Research Institute (GRI)
1. GRI-GN2 and GC13 – Joining and Attaching Geonets and Drainage Composites
 2. GRI-GN4 – Test Methods, Required Properties and Testing Frequencies for Biplaner Geonets and Biplaner Geonet Composites

1.4 Definitions

- A. Installation Contractor: Subcontractor retained by the General Contractor to install the geonet or General Contractor, if General Contractor elects to install the geonet.

1.5 Performance Requirements

- A. Installation Contractor shall furnish and install the geonet and all materials incidental to the installation in accordance with these Specifications.
- B. Alignment, lengths, and areas for geonet placement are shown on the Drawings. Exact locations and lengths may be varied to suit conditions encountered in the field only as approved by the Engineer.
- C. Installation Contractor shall furnish sufficient material to provide the finished geonet shown on the Drawings; including material for all seams and laps. Installation Contractor shall balance the actual project geonet requirements, as determined by his quantity take-offs, against those shown on the Drawings.

1.6 Submittals

- A. Submittals detailed below shall be in accordance with Section 01300.
- B. After the Contract Award:
1. Product Data: Provide manufacturer's data sheet.
 2. Sample: Submit one (5 feet by 5 feet) sample with the machine direction marked.

1.7 Delivery, Storage, and Handling

- A. Transportation: The geonet shall be packaged and shipped in such a manner that the material is not damaged or exposed to damaging substances. Transportation shall be the responsibility of the Geonet Installation Contractor unless agreed to by the Manufacturer and the Owner, in writing, prior to the initiation of shipment of geonet to the site.
- B. Off-Loading: Off-loading of the geonet is the responsibility of the Geonet Installation Contractor. No off-loading of geonet shall be performed unless the Owner's representative is present. Any damage to the rolls during off-loading shall be documented by the Owner's representative and Geonet Installation Contractor. All damaged rolls must be stored separate from the undamaged rolls until. The rolls shall be unrolled to determine the extent of the damage. The use of the roll or portions of the roll shall be only at the approval of the Engineer. The cost of evaluating, replacing or repairing rolls damaged during off-loading shall be the sole responsibility of the Installation Contractor.

- C. Storage: The geonet shall be stored according to manufacturer’s recommendations and such that it is protected from puncture, dirt, grease, gasoline, diesel fuel, water, moisture, mud, mechanical abrasion, excessive head and other causes of damage to the geotextile material.
- D. Rolls without the proper documentation shall be stored separately until all the required documentation is received and approved by the Engineer.

2.0 PRODUCTS

2.1 Material

Table 02273-1: Minimum Average Roll Values for Geonet Material (per GRI-GN4)

Property	ASTM Test Method	Minimum Average Roll Value
Thickness ¹ (min. ave.)	D 5199	200 mil
Density ² (min. ave.)	D 1505/D 792	0.950 g/cm ³
Carbon Black Content (%)	D 1603/D 4218	1.5-3.0%
Tensile Strength ³ (MD)	D 7179	180 lb/in
Compressive Strength ⁴ (min. ave.)	D 6364	120
Transmissivity ⁵	D 4716	5.0 gal/min-ft

Notes:

1. The diameter of the presser foot shall be 2.22 in. and the pressure shall be 2.9 lb./in².
2. Density is of the formulated material; the base resin will be slightly lower.
3. This is the average peak value for five equally spaced machine direction tests across the roll width.
4. Test to be conducted using Section 6.3, the movable plate method.
5. Geonets shall be tested between rigid end platens at a hydraulic gradient of 1.0; a pressure of 10,000 lb/ft², and a seating dwell time of 15 min. Test values are for machine direction only.

3.0 EXECUTION AND DEPLOYMENT

3.1 Installation

- A. Do not deploy frozen geonet.
- B. Do not deploy geonet over frozen ground.
- C. Deploy only in areas approved by the Engineer.
- D. Deploy the geonet in a downhill manner, when applicable, with the long dimensions of the panel sloping downhill.
- E. Install the overlying geomembrane liner without damaging the geonet layer or underlying geomembrane.

3.2 Seaming

- A. Use plastic wire ties of a color contrasting to the color of the geonet.
- B. Tie Spacing: According to manufacturer’s recommendations but at a minimum of 5 feet on seam perpendicular to slopes, 2 feet on seams parallel to slopes, 5 feet on seams on grades of less than 5percent, and 6 inches on seams in anchor trenches.
- C. Do not overlap.

3.3 Construction Quality Assurance

- A. Construction Quality Assurance (CQA) shall consist of:
1. Observation of geonet prior to and during deployment for dirt and debris that may clog the leak detection system.
 2. Observation of tie spacing.
 3. Observation of procedures for damage to secondary liner.

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

**SECTION 02350
GEOSYNTHETIC CLAY LINER**

1.0 GENERAL

1.1 Section Includes

- A. References
- B. Performance Requirements
- C. Submittals
- D. Delivery, Storage, and Handling
- E. Material
- F. Deployment
- G. Seaming
- H. Quality Assurance

1.2 Related Sections

- A. Section 01300 – Submittals
- B. Section 01400 – Quality Control/Assurance
- C. Section 02205 – Fill Materials
- D. Section 02223 – Filling

1.3 References

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM D 4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
 - 2. ASTM D 5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
 - 3. ASTM D 5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles
 - 4. ASTM D 5887 – Standard Test Method for Measuring the Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter
 - 5. ASTM D 5993 – Standard Test Method for Measuring Mass per Unit Area of Geosynthetic Clay Liners
 - 6. ASTM D 5994 - Standard Test Method for Measuring Core Thickness of Textured Geomembranes
 - 7. ASTM D 6243 – Standard Test Method for Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle-Punch Geosynthetic Clay Liners
 - 8. ASTM D 6496 – Standard Test Method for Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
 - 9. ASTM D 6768 – Standard Test Method for Tensile Strength of Geosynthetic Clay Liners
- B. Geosynthetic Research Institute (GRI)
 - 1. GCL3 – Geosynthetic Research Institute Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)

1.4 Performance Requirements

- A. This Work shall include the furnishing of all labor, tools, equipment, and other items necessary for the installation of geosynthetic clay liner (GCL) as shown on the Drawings. All Work shall be performed in accordance with the lines, grades, sections, and dimensions shown on the Drawings, or as directed by the Engineer

1.5 Submittals

- A. Submittals detailed below shall be in accordance with Section 01300.
- B. After the Contract Award:
 - 1. Product Data: Provide manufacturer's data regarding filtration, permeability, and mechanical properties.
 - 2. Sample: Submit one (5 feet by 5 feet) sample with the machine direction marked.
- C. During Installation:
 - 1. Manufacturer Quality Control certificates
- D. After Installation:
 - 1. At the completion of the Work, the GCL Installation Contractor shall submit the Quality Control Documentation outlined in Section 01300 and shall include at a minimum:
 - a. Typed summary tables of the field documentation including summaries of on-site field personnel, GCL panel deployment, heat-bonded test seams, samples and test results recorded during installation, if any.
 - b. A GCL record drawing showing panels and heat-bonded test locations. The record drawing shall be drawn on a 22 -inch by 34-inch sheet.
 - c. The summary tables and record drawings shall be suitable for report presentation and agency review. One (1) digital reproducible copy of the summary tables and record drawings shall be provided to the Engineer.

1.6 Delivery, Storage, and Handling

- A. Rolls shall be stored following all Manufacturer's recommendations and the requirements of ASTM D 4873.
- B. Rolls shall be stored on a flat dry surface. Store to protect the GCL from dust, dirt, and debris. All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) light.
- C. Rolls shall be handled utilizing a solid steel bar inserted through the core bar and slings or chains attached to the ends of the bar. The core bar shall be suspended from a spreader bar so that the edges of the liner are not damaged by the suspending straps or chains.

2.0 PRODUCTS

2.1 Material

- A. The GCL as referenced in the Drawings and these Specifications shall be reinforced geofilm-related GCL similar to ContainMAT manufactured by GSE Environmental of Houston, Texas, or similar which has a maximum allowable composite hydraulic conductivity of 5×10^{-10} cm/sec.
- B. The GCL shall be formulated and manufactured from polypropylene geotextiles and high swelling, containment resistant sodium bentonite.
- C. The GCL shall be manufactured reinforced by the mechanical bonding of the needle punch process to enhance the friction characteristics of the GCL and to maintain the integrity of the GCL under hydration. No glues or adhesives shall be used in lieu of the needle punch process so as to retain these characteristics.
- D. Needle-punched GCL's are those which, by the process of a needling board (similar to that used in the manufacture of standard non-woven geotextiles) have fibers of a non-woven geotextile pushed through the bentonite clay core and integrated into a woven or non-woven geotextile without the use of any chemical binders or adhesives.

- E. No disassociation of geotextile components from the bentonite core shall occur. A sample of the GCL placed in 70° F tap water for 1 hour shall not delaminate.
- F. The GCL supplied to the project shall meet or exceed the minimum (unless noted otherwise) roll values shown in the table below:

Table 02350-1: Minimum Average Roll Values For Reinforced Geofilm Related GCL Material (per GRI-GCL3)

PROPERTY	ASTM TEST METHOD	VALUE
Geotextile/Geofilm Properties		
Cap Geosynthetic		
Type	-	Non-woven
Weight	ASTM D 5261	6.0 oz/sq.yd.
Carrier Geosynthetic		
Type	-	Woven
Weight	ASTM D 5261	3.0 oz/sq.yd.
Geofilm		
Thickness	ASTM D 5199/ D 5994	4 mil
Break Tensile Strength (MD & XMD)	ASTM D 882	12 lb/in
Clay Properties		
Clay Type	-	80% or more montmorillonite
Bentonite Mass at 0% Moisture ²	ASTM D 5993	0.75 psf
Maximum Allowable Moisture Content	ASTM D 5993	35%, by weight
Swell Index	ASTM D 5890	24 ml/2g min
Fluid Loss	ASTM D 5891	18 ml max
GCL Composite Properties		
GCL Permeability ¹	ASTM D 5887	5 x 10 ⁻¹⁰ cm/sec max at 5.0 psi
Tensile Strength in Machine Direction	ASTM D 6768	23 lb/in
Peel Strength	ASTM D 6496	2.1 lb/in
Geofilm Durability ⁴	ASTM D 5721	80% strength
Internal Shear Strength	ASTM D 6243	150 psf typical

Notes:

1. Maximum allowable permeability per Golder.
2. For both cap and carrier fabrics for non-woven reinforced GCLs; one, or the other, must contain a scrim component of mass > 2.9 oz/sq.yd. for dimensional stability. This only applies to GM/GCL composites which are exposed to the atmosphere for several months or longer so as to mitigate panel separation.
3. If the GCL is manufactured at a higher moisture content, it shall have a minimum of 1 psf of bentonite when adjusted to a 12% moisture level.
4. Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60° C for 50 days.

- G. Rolls shall be manufactured a minimum of 15.5 feet wide and 150 feet long. A minimum 6-inch lap line and a 9-inch match line shall be printed on both edges of the woven geotextile of the GCL (the upper surface as installed) to assist in overlap quality control.
- H. The GCL will be warranted by the Manufacturer to be free from defects in materials and workmanship and to have a useful life of 5 years from the date of purchase under normal weathering and normal use.

3.0 EXECUTION AND DEPLOYMENT

3.1 Deployment

- A. Procedure and methods shall not damage the GCL. Manufacturer's recommended deployment techniques shall be followed by the Contractor to the greatest extent possible.
- B. Prior to deployment of the GCL, the subgrade shall be final graded and rolled to provide a smooth surface free of any soft areas, rocks protruding greater than 1/2 inches above the subgrade, or ruts in accordance with Section 02223. Subgrade shall also be free from any chemicals which could damage the GCL. The subgrade shall be approved by the Engineer prior to GCL deployment.
- C. Panels shall be placed with the non-woven side against the subgrade and the woven polypropylene coated side oriented upwards. The GCL shall be smoothed to be free of wrinkles and creases.
- D. The Contractor shall only Work on an area that can be completed in one working day. Completion shall be defined as the full installation of the liner and placement of the geomembrane liner. The GCL shall be covered immediately to protect it from any precipitation that may occur during construction.
- E. Whenever possible, direct contact to the GCL will be avoided. If access requires travel over the GCL, the Contractor shall use low ground pressure (LGP) that exerts 7.0 psi or less to the contact area of GCL. Equipment tracks shall be made of rubber. Care shall be taken to avoid sharp turns and any quick stops or starts so as to avoid pinching or moving the GCL. Any damage caused by direct contact to the GCL will be repaired at the Contractor's expense.
- F. The Contractor shall keep the GCL dry during installation. Installation shall not take place during high humidity, rain, or other types of precipitation. Any GCL which becomes hydrated prior to covering with drainage layer material or protective soil shall be removed and replaced at the Contractor's expense.

3.2 Seaming

- A. Seams shall be flat without wrinkles and shall be overlapped a minimum of 18-inches on all sides.
- B. Granular bentonite shall be placed between the upper and lower panels for a minimum width of 12-inches at a rate of the-quarter (1/4) pound per lineal foot of seam.
- C. All seams shall be continuously heat-bonded together. Heat bonding techniques shall be approved by the Engineer. Care shall be taken to not place granular bentonite where it may interfere with heat-bonding of the seam.
- D. Repair Procedures:
 - 1. Rips, tears, or holes in the GCL shall be repaired by completely exposing the affected area, removing all foreign objects or soil, and then placing a patch over the defect, with a minimum overlap of 18-inches on all edges.
 - 2. All seams shall be continuously heat-bonded to the underlying GCL panel.
 - 3. Granular bentonite shall be placed between the patch and the repaired material at a rate of one-quarter (1/4) pound per lineal foot of edge.
 - a. Defective seams, tears, and holes, shall be repaired as described above.
 - b. Blisters, large holes, undispersed raw materials, and contamination by foreign matter shall be repaired by patches.

3.3 Quality Assurance

- A. Quality Assurance shall consist of:
 - 1. Review of required documentation.
 - 2. Approval of GCL rolls for deployment.
 - 3. Observation of unrolled material for damage.
 - 4. Observation of seaming procedure and completed seams.
- B. Engineer has final authority in the Quality Assurance for the project.
- C. Compliance Testing:
 - 1. At the option of the Engineer, compliance testing may be performed at any time prior to, during, or after the installation.
 - 2. The cost of the compliance testing shall be negotiated between the Owner and Contractor.
 - 3. The tests performed for the compliance testing shall be directed by the Engineer.
 - 4. Compliance testing shall not include any tests that are not listed in these Specifications as a basis for evaluating compliance of the GCL to the Specifications.
 - 5. Sampling for Compliance Testing:
 - a. Samples shall be obtained by the Engineer.
 - b. The sample shall be taken as close to the middle of the roll as practical but shall, at a minimum, be sampled no closer than three (3) feet from the end of a roll.
 - 6. The sample shall be labeled by the Engineer, using a permanent marker, with the roll number, machine direction, date sampled, and name of individual that sampled the material.
- D. Seams:
 - 1. Will be observed for required overlap and seaming procedures.
 - 2. Seams that do not have the required overlap will be marked for adjustment.

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

SECTION 02710 GRAVITY PIPING

1.0 GENERAL

1.1 Section Includes

- A. Related Sections
- B. References
- C. Submittals
- D. Piping
- E. High Density Polyethylene Pipe and Fittings
- F. Fabrication
- G. Handling and Storage
- H. Installation
- I. Pipe Connections
- J. Bedding and Backfill

1.2 Related Sections

- A. Section 02205 – Fill Materials
- B. Section 02222 – Excavating
- C. Section 02223 – Filling
- D. Section 11207 – Parshall Flumes
- E. Section 03300 – Cast-in-place Concrete

1.3 References

- A. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe
- B. ASTM D1693 – Standard Test Method for Environmental Stress Cracking Ethylene Plastics
- C. ASTM 2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and other Gravity Flow Applications
- D. ASTM D3350 – Standard Specification for Polyethylene Plastic Pipe and Fittings Materials.
- E. ASTM D3261 – Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

1.4 Submittals

- A. Submit the following under provisions of Section 01300:
 - 1. The Contractor shall provide detailed information to the Owner and Engineer for: pipe, valves, fittings, and joining manufacturer's data, including type/class, method of joining, specifications, manufacturer's name, and manufacturer's certificate of compliance.
 - 2. If an equivalent product is proposed, submit samples, technical data, test data, and specifications sufficient to allow evaluation by Engineer.

2.0 PRODUCTS

2.1 Pipe

- A. Tailings Storage Facility Underdrain Collection Piping
 - 1. 6-inch diameter perforated Underdrain Outlet Pipe (HDPE DR17)
 - 2. 6-inch diameter solid wall Underdrain Outlet Pipe (HDPE DR17)

3. 6-inch diameter, 20-foot long with 3-inch wide water stop Underdrain Outlet Pipe (HDPE DR17)
 4. 6-inch diameter perforated CPE Underdrain Collection Pipe
 5. 4-inch diameter perforated CPE Underdrain Collection Pipe
- B. Waste Rock Dump Underdrain Collection Piping
1. 6-inch by 10-inch diameter dual containment Underdrain Outlet Pipe (HDPE DR17)
 2. 6-inch diameter perforated Underdrain Outlet Pipe (HDPE DR17)
 3. 6-inch diameter perforated CPE Underdrain Collection Pipe
 4. 4-inch diameter perforated CPE Underdrain Collection Pipe
- C. Reclaim Pond
1. 10-inch diameter solid wall Leak Detection Riser Pipe (HDPE DR17)

2.2 High Density Polyethylene Pipe and Fittings

- A. The polyethylene pipe and fittings shall meet or surpass the physical property values. Pipe and fittings shall be made of polyethylene compounds which meet or exceed the requirements of Type III, Category 4 or 5, Grade P33 or P24, Class C per ASTM D 1248. Pipe fittings shall be manufactured from the same resin and by the same pipe Manufacturer.
- B. HDPE pipe material shall be PE4710. The PE4710 material shall conform to ASTM D 3350 with the cell classification of 445574C.
- C. All pipe shall comply with ASTM F 714.
- D. The polyethylene compound shall contain a minimum of 2 percent carbon black to withstand outdoor exposure without loss of properties. The polyethylene compound shall have a minimum resistance of 5,000 hours when tested for environmental stress crack in accordance with requirements of ASTM D 1693.
- E. Minimum parallel plate pipe stiffness values at 5% deflection shall be 50 psi per test method ASTM D 2412.
- F. Pipes and fittings shall be homogenous throughout and free of visible cracks, holes (other than intentional manufactured perforations), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index, and other physical properties.
- G. Fittings at the ends of pipes shall consist of polyethylene unless indicated otherwise on the Drawings. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without the approval of the Engineer. HDPE fittings shall be in accordance with ASTM D 3261.
- H. Segments of pipe having cuts or gouges in excess of 10% of the wall thickness of the pipe shall be cut out, removed, and replaced.
 - I. The standard dimension ratio (DR) for the piping shall be as shown on the Drawings.
 - J. Where polyethylene pipe is to be slotted, slots shall be completed at the manufacturing plant or by the Contractor prior to installation of the Work.
- K. Polyethylene pipe shall be supplied in standard laying lengths not exceeding 50 feet.
- L. Underdrain water stop segments shall be cast-in-place to the lines and grades shown on the Drawings for the underdrain outlet pipes at the upstream toe of the Stage 1 embankment. Underdrain Pipe water stops shall be constructed of 20-foot long pipe segments with continuous 3-inch wide by ½-inch thick rig factory-fabricated at the midpoint of the segment length.

2.3 Valves

- A. Butterfly Valve:

1. 6-inch gear operated butterfly valve, Class 150 manufactured by a company whose products are approved by the Engineer. Valve bodies shall be cast iron, ductile iron, or other approved material mounted with approved non-corrosive metals. All wearing surfaces shall be bronze or other approved non-corrosive materials compatible with the sodium cyanide solution used for the Project. There shall be no moving, bearing, or contact surfaces of iron in contact with iron. Contact surfaces shall be machined and finished in the best workmanlike manner, and all wearing surfaces shall be easily renewable or replaceable.
- B. The valves shall be standard pattern of the Manufacturer whose products are approved by the Engineer. The valves shall have the name or mark of the Manufacturer, year valve casting was made, size, and working pressure plainly cast in raised letters on the valve body.

2.4 Fabrication

- A. Finished pipe lengths shall have beveled ends for field welding.
- B. Pipe shall be fabricated in accordance with manufacturer's recommendations and ASTM F 2620.
- C. Underdrain water stop segments shall be prefabricated in the manufacturing facility. Pipe segment shall be a minimum of 20 feet long and suitable for field butt fusion welding.

3.0 EXECUTION

3.1 Handling and Storage

- A. Transportation of pipe, valves, and fittings shall be the responsibility of the Contractor. The Contractor shall be liable for all damage to the pipe, valves, and fittings incurred prior to and during transportation to the site.
- B. Handling, storage and care of the pipe, valves, and fittings prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damage to the material incurred prior to final acceptance by the Engineer.
- C. The Contractor shall be responsible for storage of pipe, valves, and fittings at the site. Pipe, valves, and fittings shall be stored on clean level ground, which is free of sharp objects which could damage these materials. Stacking shall be limited to a height that shall not cause excessive deformation of the bottom layers of pipe under anticipated temperature conditions. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitable and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

3.2 Installation

- A. There is no guarantee that existing utilities are properly located or that other utilities are not present. It shall be the Contractor's responsibility to request locates, confirm locates, expose, and protect all nearby utilities or other potential subsurface facilities that may interfere with the work.

3.3 Work Staging Area

- A. Installation of piping, fittings, and valves shall be done to replace existing damaged or malfunctioning parts, as directed by the Engineer.
- B. Install all piping, fittings, and valves according to manufacturer's recommendations.

3.4 Pipe Connections

- A. All connections for the piping system shall be watertight under maximum anticipated pressure head.
- B. The ends of all pipe shall be capped with a manufactured pipe cap unless otherwise noted on the Drawings.
- C. TSF underdrain outlet pipe cast-in-place water stops shall be prefabricated.
- D. HDPE pipe shall be butt-heat-fusion welded in accordance with the manufacturer's guidelines and ASTM D3261 unless otherwise noted on the Drawings.

- E. Perforated to solid wall HDPE pipe connections at the upstream toe of the Stage 1 embankment within the basin shall be electrofusion couplings.

3.5 Bedding and Backfill

- A. Pipe Bedding Fill shall be placed only in the locations shown on the Drawings.
- A. Backfill and compact Pipe Bedding Fill in accordance with Section 02223.
- B. Pipe Bedding Fill shall be hand-worked under the haunches of the pipe to uniformly bed and support the pipe.

3.6 Tolerances

- A. Grade surface in a manner so that piping can be laid straight at a uniform grade, without sags or humps.

3.7 Quality Control

- A. A short description of the Quality Control program shall be submitted by the Contractor with the bid to the Engineer and Owner. This description shall state the Quality Control standard to be used and as a minimum containing the following:
 - 1. An organization chart with a brief job description of Quality Control function
 - 2. A list of applicable procedures for implementation of the Quality Control program
 - 3. A general description of how each Quality Control requirement is to be fulfilled during the design, procurement, manufacture, assembly and testing
- B. During award phase, the Quality Control documentation shall be forwarded to the Engineer as specified in Section 01300. Pertinent Quality Control documentation including Quality Control manuals shall be approved by the Engineer prior to any production work commencing. A minimum of five working days shall be allowed for the Engineer's review.
- C. Upon delivery of the pipe, the Contractor shall forward the following documentation:
 - 1. All Vendor certificates and tests performed per these Specifications
 - 2. All Vendor documents verifying that inspection, control, and tests performed are in accordance with these Specifications
 - 3. Identification lists with cross references between documents and hardware/materials for traceability purposes
- D. The Engineer or Owner shall have the right to carry out audits at the Contractor's, Vendor's, and their subcontractor's facilities, to verify compliance with all aspects of the documentation included in the purchase order. For the purpose of evaluating and auditing, the Contractor, Vendor, and their subcontractors shall give free access to all facilities concerned and to all the Quality Control documents and records
- E. Applicable records may be requested by the Engineer or Owner at any time during production, these shall be forwarded to the Engineer or Owner upon request within five working days. The Contractor or Vendor shall give a written response to the Engineer or Owner for any corrective action requests and if requested, take the necessary corrective action in a timely manner

3.8 Mechanical Properties Testing

- A. All mechanical properties shall be tested and records submitted per applicable codes and Vendor standards.

3.9 Non-Destructive Examination Requirements

- A. All non-destructive examinations and records shall be submitted per applicable code and Vendor standards

3.10 Hydrostatic Pressure Tests

- A. All piping must be hydrostatically tested per ASME B31.11 and the pipe class sheets. Test records shall be submitted by the Contractor as part of the turnover package
- B. The Contractor shall continuously monitor the hydrostatic pressure throughout the test, from the start of pressurization to the completion of depressurization. Suitable equipment shall be used to provide a continuous record of test pressure, time and the ambient temperature.
- C. Hydrostatic test gauges shall be calibrated prior to the commencement of production and shall be recalibrated weekly. Certified dead weight testers shall be used for calibration. The Engineer shall witness the calibration of the gauges.
- D. The hydrostatic pressure test shall show no variation in pressure which is not directly related to a change in recorded temperature. The test medium shall be clean, filtered non-saline potable water with added corrosion inhibitors. The inhibited water shall be free from sand, dirt and organic material. The hydrostatic testing records and certificates shall be identified to the individual pipe section numbers.
- E. No welding shall be allowed after hydrostatic testing has been completed.

3.11 Supplemental Requirements

- A. The Contractor shall submit the Vendor's schedule showing the complete plan for drawing submittal, manufacturing, testing and delivery to site. This schedule shall include hold points pertaining to the entire Work.
- B. The Engineer reserves the right to enter the Contractor's, Vendor's, or any Subcontractor's facility, at any time, with 48 hours prior written notice, for verification of Work. The Engineer shall have the right to reject any and all materials or order the rework of any and all parts and components not meeting these Specifications at no additional cost to the Owner.
- C. The Contractor shall provide the Engineer with all Vendor inspection records, laboratory certificates and any other documentation deemed by the Engineer to be required for verification of materials used or work done. The Contractor shall keep Vendor's records of chemical and physical mill certifications for all materials. These records shall be made available to the Engineer and Owner, upon request.
- D. The Contractor or Vendor shall be responsible for the inspection, Quality Assurance and Quality Control of the all the Vendor's work. The Engineer reserves the right to supplement and amend the Contractor's or Vendor's Quality Control program if determined necessary at any time.
- E. Certification of all levels of personnel is the responsibility of the Vendor. A Vendor who purchases outside services is responsible for assuring that training and examination services are in accordance with the Vendor's written practices and these Specifications.

3.12 Repair of Defects

- A. All defect repair procedures require written approval by the Engineer.
- B. Defects are to be reported to Engineer as soon as they are identified.
- C. HDPE pipe repairs and defects:
 - 1. Items that contain defects shall be rejected or repaired. Such injurious defects include defects that reduce the mechanical properties, such as internal or external surface gouges, scars, scratches, blisters, or discontinuities that produce a notch effect or reduce the specified pipe wall thickness by 10% or more.
 - 2. The Contractor shall mark all bonds that have been examined and accepted inspected per the pipe manufacturer's recommended inspection method. All bonds requiring repair shall be marked as defective. When a repaired bond is subsequently accepted, it shall be marked over with green paint signifying its acceptance. The marking shall be done in such a manner so as to enable the Quality Assurance Team, Engineer, and Contractor to determine the status of the bonds on the pipeline.
 - 3. All repairs made to defects shall be re-inspected using the same inspection methods recommended by the pipe manufacturer.

4. Butt-heat-fusion welds that do not meet the acceptance criteria as noted in these Specification, Manufacturer's recommendations, or any Code shall be completely removed. All butt-heat-fusion welds are subject to visual inspection.

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

SECTION 02775 GEOMEMBRANES

1.0 GENERAL

1.1 Summary

- A. This Section describes requirements for the manufacture and installation of geomembrane liner materials for the tailings storage facility.
- B. The Work includes furnishing all labor, tools, equipment, and supervision required to install the geomembrane in accordance with the Drawings and these Specifications.

1.2 Related Sections

- A. Section 01300 – Submittals
- B. Section 01400 – Quality Control/Assurance
- C. Section 01500 – Testing Laboratory Services
- D. Section 02205 – Fill Materials
- E. Section 02211 – Rough Grading
- F. Section 02223 – Filling
- G. Section 02273 – Geonet
- H. Section 02350 – Geosynthetic Clay Liner

1.3 References

- A. The publications listed below form a part of this Section to the extent referenced. The publications are referred to in the text by basic designation only.
 - 1. American Society for Testing and Materials (ASTM)
 - a. ASTM D 792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
 - b. ASTM D 882 – Standard Test Method for Tensile Properties of Thin Plastic Sheeting
 - c. ASTM D 1004 – Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
 - d. ASTM D 1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique
 - e. ASTM D 1603 – Standard Test Method for Carbon Black in Olefin Plastics
 - f. ASTM D 1790 – Standard Test Method for Brittleness Temperature of Plastic Sheeting by Impact
 - g. ASTM D 3895 – Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
 - h. ASTM D 4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
 - i. ASTM D 4833 – Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
 - j. ASTM D 5199 – Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
 - k. ASTM D 5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
 - l. ASTM D 5397 – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembrane Using Notched Constant Tension Load Test
 - m. ASTM D 5596 – Standard Test Method Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

- n. ASTM D 5721 – Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
- o. ASTM D 5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Colorimetry
- p. ASTM D 5994 – Standard Test Method for Measuring Core Thickness of Textured Geomembrane
- q. ASTM D 6392 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
- r. ASTM D 6693 – Standard Test Method Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
- s. ASTM 7003 - Standard Test Method for Strip Tensile Properties of Reinforced Geomembranes
 - 2. Geosynthetic Research Institute (GRI):
 - a. GM10 – Specification for Stress Crack Resistance of Geomembrane Sheet
 - b. GM13 – Test Properties, Testing Frequency, and Recommended Warranty for HDPE Smooth and Textured Geomembranes
 - c. GM19a – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.4 Submittals Prior To Construction

- A. The Geomembrane Installation Contractor shall provide the following information to the Owner prior to mobilization:
 - 1. Manufacturer information including; company name, address, telephone number, the names of the company president and quality control manager, and narrative of the company history. Additional information required includes factory size and production capability.
 - 2. Quality Control Manuals from the Manufacturer and Geomembrane Installation Contractor for the installation and testing of the geomembrane, including trial seams, seaming, nondestructive testing, destructive testing procedures, repair procedures and in-field quality control forms. Upon review of the Quality Control Manuals, the Owner may request additional testing during the manufacturing process at no additional cost to the Owner.
 - 3. A list of at least five completed facilities from the Manufacturer totaling a minimum of 5,000,000 square feet of the type of geomembrane that is being installed for this project. Each entry in this list should specify the name and purpose of the facility, its location and date of installation, the name of the Owner, the project manager, designer, fabricator (if any), and Geomembrane Installation Contractor and the name and telephone number of the contact at the facility who can discuss the project. In addition, the geomembrane thickness and total square footage of the installation surface should be included.
 - 4. A list of at least five completed facilities, totaling 5,000,000 square feet for which the Geomembrane Installation Contractor has installed the type of geomembrane that is being installed for this project. For each installation, the following information shall be provided:
 - a. Name and purpose of facility, its location, and date of installation
 - b. Name of Owner, design engineer, manufacturer, fabricator, if applicable, and name and telephone number of the contact at the facility who can discuss the project
 - c. Geomembrane type and surface area of the installed geomembrane
 - d. Type of seaming, patching, and tacking equipment
 - e. A copy of the Manufacturer's and/or fabricator's approval letter(s) and/or license(s), if applicable
 - f. applicable
- B. The Geomembrane Installation Contractor shall provide the following information 14 days prior to geomembrane arrival on-site and prior to commencement of the Work:

1. A copy of each of the Quality Control Certificates on each lot of resin issued by the resin Supplier for the specific material at this project including certification of the resin for extrusion welding.
 2. The results of Quality Control testing conducted by the Manufacturer on the resin used in manufacturing the specific material for this project.
 3. A listing that correlates the resin to the individual geomembrane rolls and welding rods.
 4. A copy of the geomembrane roll Quality Control Certificates. These certificates shall be supplied at a minimum frequency of one per every 50,000 square feet of geomembrane material produced. These certificates shall be issued only for the individual geomembrane rolls sampled and tested by the Manufacturer or its representative. The certificates shall contain test results of properties outlined in Article 2.1 of this Section. The Engineer reserves the right to refuse use of any geomembrane supplied without the proper quality control documentation at no cost to the Owner.
 5. A detailed list of performance criteria for the geomembrane material being produced for this project. (Note: Performance criteria are sometimes referred to as "minimum property values". Refer to Articles 2.1 of this Section for geomembrane properties and Test Methods).
 6. Resumes from the Geomembrane Installation Contractor of the Installation Superintendent, Master Seamer, and Quality Control Inspector to be assigned to the work, including dates and duration of employment.
 7. Certification from the Geomembrane Installation Contractor that Installation Supervisor, Quality Control Inspector, and Master Seamer have reviewed the Specifications, Construction Quality Assurance Plan, and the Drawings.
 8. A panel layout drawing showing the proposed installation layout identifying field seams and including areas such as sumps, trenches and pipe penetrations as well as any variance or additional details that deviate from the Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. Any proposed variance or deviation from these documents shall be submitted to the Engineer in writing a minimum of seven working days prior to the scheduled start of geomembrane installation and shall be accepted/rejected by the Engineer prior to start of installation.
 9. A list of personnel performing field seaming operations along with pertinent experience information.
 10. Certification that extrudate to be used is comprised of the same resin as the geomembrane to be used.
- C. The Geomembrane Installation Contractor shall provide the following information daily to the Engineer during the course of the work:
1. Summaries of geomembrane panel deployment, field test seams, fusion and extrusion seams, extrusion seam repairs, nondestructive seam tests, seam pressure tests, defects and repairs, and seam destructive samples and test results recorded during installation.
 2. Daily reports detailing arrival and departure times, the personnel present on-site, the progress of the Work, the arrival of materials, and any problems encountered.
 3. Geomembrane record drawings identifying the panels, seams, and test locations. The Quality Control Inspector's geomembrane record drawing shall be made available for review by the Engineer at any time during the day.
 4. Subgrade surface acceptance certificates for each area to be covered by the lining system, signed by the Geomembrane Installation Contractor.
 5. It is the Quality Control Inspector's responsibility to ensure that the documentation is checked for errors and conflicts prior to submitting the documentation to the Engineer. The daily field documentation and record drawings shall be completed in a neat and professional manner.

1.5 Submittals After Construction

- A. At the completion of the Work, the Geomembrane Installation Contractor shall submit the Quality Control Documentation outlined in Section 01300 and shall include at a minimum:

1. Typed summary tables of the field documentation including summaries of on-site field personnel, geomembrane panel deployment, field test seams, fusion and extrusion seams, extrusion seam repairs, nondestructive seam tests, seam pressure tests, defects and repairs, and seam destructive samples and test results recorded during installation.
2. A geomembrane record drawing showing panels and destructive test locations. The record drawing shall be drawn on a 22-inch by 34-inch sheet and in AutoCAD .dwg electronic format.
3. The summary tables and record drawings shall be suitable for report presentation and agency review. One (1) digital reproducible copy of the summary tables and record drawings shall be provided to the Engineer.

1.6 Quality Control

- A. The geomembrane Manufacturer shall have the following qualifications:
 1. Experience in the manufacture of the type of geomembrane that is being installed for this project totaling at least five completed facilities totaling a minimum of 5,000,000 square feet.
 2. Sufficient production and qualified personnel to meet the demands of the work and shall have an internal quality control program for its product.
 3. Shall permit the Quality Assurance Team, Engineer, or their authorized representatives to visit the manufacturing plant.
- B. The Geomembrane Installation Contractor shall have the following qualifications:
 1. The Manufacturer or an approved Geomembrane Installation Contractor trained and certified to install the Manufacturer's geomembrane.
 2. Installation shall be performed under the constant direction of a single Installation Superintendent who shall remain on-site and be responsible, throughout the geomembrane installation, for geomembrane layout, seaming, patching, testing, repairs, and all other installation activities related to geomembrane installation.
 3. The Installation Superintendent shall have installed or supervised, at a minimum three installation projects that entailed the installation of at least a total of 1,000,000 square feet of the type of geomembrane that is being installed for this project.
 4. Actual seaming shall be performed under the direction of a Master Seamer who has seamed a minimum of 1,000,000 square feet of the type of geomembrane that is being installed for this project, using the same type of seaming equipment specified for the Work.
 5. The Installation Superintendent and/or Master Seamer shall be present whenever seaming is performed.
- C. All Work shall be constructed, monitored, and tested in compliance with the requirements of these Specifications. The Geomembrane Installation Contractor and Manufacturer shall participate in and comply with all items in these Specifications.
- D. The Geomembrane Installation Contractor shall ensure that geomembrane material supplied to this project has an internal product quality control program that meets Specifications.
- E. During manufacturing of the geomembrane, samples of geomembrane shall be removed for laboratory conformance testing to ensure compliance with these Specifications. Conformance sampling and testing shall be performed by the Quality Assurance Team in accordance with Article 3.11 of this Section.
- F. The Contractor shall assure that the geomembrane is delivered to the site at least 14 calendar days prior to installation. The Contractor shall provide required Quality Control information to the Quality Assurance Team and the Engineer 14 calendar days prior to geosynthetics being delivered to this project and on delivery of geosynthetics to the project site.

- G. Geomembrane rolls that do not meet the requirements of this Specification shall be rejected. The Contractor shall replace the rejected material with new material that conforms to the Specification requirements, at no additional cost to the Owner.
- H. The Geomembrane Installation Contractor shall ensure that all personnel performing geomembrane seaming operations are qualified by experience or by successfully passing seaming tests in accordance with Article 3.7 of this Section. The Engineer reserves the right to reject any welding technician whose performance is unsatisfactory.
- I. The Geomembrane Installation Contractor's Installation Superintendent and QC Inspector shall attend the pre-construction meeting.
- J. The Geomembrane Installation Contractor shall perform Quality Control during geomembrane installation in accordance with the Quality Control Manual.
- K. Field Samples
 - 1. Geomembrane sampling and testing shall be conducted in accordance with the project Specifications for the following:
 - a. Trial seam testing (Article 3.7 of this Section)
 - b. Non-destructive seam testing (Article 3.8 of the Section)
 - c. Destructive seam testing (Article 3.9 of this Section)
 - 2. The Geomembrane Installation Contractor shall maintain on-site a minimum of one spare operable tensiometer and provide documentation indicating that all tensiometers used at the project were calibrated within 60 days prior to the tensiometer arriving on-site for testing field samples.
- L. In order to prevent wind damaged geomembrane from being placed, the following Quality Control procedures shall be followed:
 - 1. The Geomembrane Installation Contractor shall utilize sufficient ballast as necessary to prevent wind uplift of the geomembrane panels.
 - 2. If wind damage should occur, the Engineer shall determine if the geomembrane shall be repaired or replaced. Wind damage to the geomembrane shall include wrinkles, creases, and tears, as determined by Engineer.
 - 3. Repair or replacement of the wind-damaged geomembrane shall be completed by the Geomembrane Installation Contractor at no additional cost to the Owner.
 - 4. As determined by the Engineer, the geomembrane panel may be rejected at no cost to the Owner.
- M. In order to prevent thermal stress damage to installed geomembrane, the following Quality Control procedures shall be followed:
 - 1. The Geomembrane Installation Contractor shall perform its Work and utilize sufficient slack as necessary for temperature compensation to prevent bridging or trampolining of the installed geomembrane.
 - 2. If bridging or trampolining should occur, the Engineer shall determine if the geomembrane shall be repaired or replaced.
 - 3. Repair or replacement of the bridging or trampolining geomembrane shall be completed by the Geomembrane Installation Contractor at no additional cost to the Owner.

1.7 Delivery, Storage, and Handling

- A. Packing and Shipping
 - 1. Labels on each roll delivered to site shall identify the following:
 - a. Manufacturer's Name
 - b. Product Identification

- c. Thickness
 - d. Roll number
 - e. Batch or resin lot number
 - f. Panel number (when applicable)
 - g. Roll dimensions
 - h. Roll weight
2. The Geomembrane Installation Contractor shall ensure that geomembrane rolls are properly loaded and secured to prevent damage during transit in accordance with the Manufacturer's recommendations.
 3. The Geomembrane Installation Contractor shall protect geomembrane from excessive heat, cold, puncture, cutting, or other damaging or deleterious conditions in accordance with Manufacturer's recommendations.
 4. The Geomembrane Installation Contractor shall ensure personnel responsible for loading, transport, and unloading of geomembrane are fully aware of the consequences of damage to geomembrane and are familiar with handling and transport constraints in accordance with the Manufacturer's recommendations.
 5. Geomembrane shall be supplied in rolls with straps for unloading.
- B. Acceptance at Site
1. The Quality Assurance Team or Engineer shall perform inventory and surface inspection for defects and damage of all geomembrane rolls upon delivery.
 2. The Geomembrane Installation Contractor shall unroll and inspect any geomembrane roll that may be damaged below the outer surface of the roll.
 3. The Geomembrane Installation Contractor shall repair damage resulting from handling and transport of geomembrane at no additional cost to the Owner. If irreparable, in the opinion of the Quality Assurance Team or the Engineer, damaged materials shall be replaced at no additional cost to the Owner.
- C. Storage and Protection
1. The Owner shall provide area for on-site storage of the geomembrane rolls from time of delivery until installation.
 2. The storage and handling of the materials is the responsibility of the Geomembrane Installation Contractor from the time the materials are manufactured until the time the completed installation is accepted by the Engineer. The Geomembrane Installation Contractor is responsible for preparing the storage location and for the protection of the materials from the elements (e.g. ultraviolet light, moisture, temperature, etc.).
 3. The rolls shall be stored on a prepared continuous surface free of large protrusions (e.g. not wooden pallets) and should not be stacked more than two rolls high. Proper blocking shall be used to prevent rolls from moving (e.g. tire chocks).
 4. After the Geomembrane Installation Contractor has removed material from storage, the Geomembrane Installation Contractor shall protect geomembrane from puncture, dirt, grease, water, moisture, mud, mechanical abrasion, excessive heat and other sources of damage.
 5. The Geomembrane Installation Contractor shall preserve integrity and readability of the geomembrane roll labels and store the rolls such that the Engineer has access to the package slips or roll labels for each roll to verify roll acceptance.

1.8 Site Conditions

- A. Geomembrane Deployment

1. Do not proceed with deployment at an ambient temperature below 14°F or above 100°F unless otherwise authorized, in writing, by the Engineer.
 2. Do not deploy during precipitation, in the presence of excessive moisture (e.g. fog, dew, frost, rain, snow, sleet, hail), in an area of ponded water, or in the presence of excessive winds.
 3. Do not undertake deployment if weather conditions shall preclude material seaming on same day as deployment.
- B. Seaming
1. Normal Weather Conditions. Normal seaming procedures may take place if the following weather conditions exist:
 - a. Ambient temperature between 35°F and 100°F
 - b. Dry conditions, i.e., no precipitation or other excessive moisture, such as fog, dew, rain, snow, sleet, or hail
 - c. No excessive winds
2. Adverse Weather Conditions
 - a. Do not seam if ambient temperature is below 14°F or above 102°F
 - b. Do not seam during precipitation, in the presence of excessive moisture (e.g. fog, dew, frost, rain, snow, sleet, hail), in an area of ponded water, in the presence of excessive winds
 - c. If the ambient air temperature is between 14°F and 35°F for the entire shift, the following Cold Weather Seaming provisions shall govern:
 - i. In accordance with these Specifications, trial seaming shall be conducted under the same ambient temperature and condition as the production seams. A minimum of four trial seams for each welding apparatus shall be required during the shift, at approximately the same time interval throughout the scheduled work day; additional trial seams may be required, at the discretion of the Quality Assurance Team or Engineer.
 - ii. If the subgrade is frozen, geomembrane rub-sheets will be placed between the liner and the subgrade during fusion welding of the seams.
 - iii. It may be necessary for the Geomembrane Installation Contractor to pre-heat the liner using a hand-held leister type device during field seaming. If this procedure is used, a trial seam for each welding apparatus shall be performed using the same technique.
 - iv. Destructive testing for peel adhesion shall be conducted at the beginning and end of each extrusion welded seam in excess of 25 feet. The coupon sample shall exhibit a film tear bond (FTB) type of failure and may be pulled by hand by the welding technician using vice grip pliers. The testing shall be witnessed by the Quality Assurance Team.
 - v. Destructive testing frequencies may be increased at the discretion of the Quality Assurance Team and/or the Engineer.
 - vi. Air testing/vacuum testing of the seams/patches shall be performed on the same day as the welding, to ensure any potential problems are identified as early as possible.
 - vii. All patches shall be completed by the end of shift.

2.0 PRODUCTS

2.1 Materials

- A. The geomembrane shall be 60-mil smooth and 80-mil double sided textured high-density polyethylene (HDPE) as shown in the Drawings. The geomembranes shall be manufactured of new, first-quality resin produced in the United States and shall meet or exceed all manufacturing requirements and recommendations for HDPE geomembranes specified by the American Society for Testing and Material (ASTM) and the Geosynthetics Research Institute (GRI).

- B. All geomembrane shall be manufactured by the same manufacturer using the same resin compound or mixture. Geomembrane from more than one manufacture for each phase of Work shall not be permitted unless approved by the Engineer. If geomembrane between phases is of different manufacturing origin, prior to installation, documentation shall be provided to the Engineer showing that welds between both manufacturers' geomembrane meet the minimum requirements of these Specifications for seaming.
- C. The geomembrane sheet shall be comprised of a minimum 96 percent pure polyethylene. The remaining portion shall be made up of materials necessary for the performance of the liner (such as carbon black, anti-oxidants, etc.) The geomembrane rolls shall meet the following Specifications:
1. The surface of the geomembrane shall not have striations, roughness (except texture as specified), pinholes, or bubbles and shall be free of holes, blisters, undispersed raw materials, or any contamination by foreign matter. The Engineer may request additional testing in order to support such acceptance. All such testing shall be done at the sole expense of the Geomembrane Installation Contractor.
 2. The geomembrane supplied for the project shall meet or exceed the minimum values and testing requirements:

Table 02775-1: Required Minimum Geomembrane Properties for Textured HDPE Geomembrane (per GRI-GM13)

Property	Test Value		Test Method	MQC Testing Frequency
	60 mil	80 mil		
Thickness mils (min avg.)	57 mil	76 mil	ASTM D 5994	Per Roll
Thickness (Minimum 8 of 10)	-10% (54 mil)	-10% (72mil)		
Lowest individual for any of the 10 values	-15% (51 mil)	-15% (68 mil)		
Asperity Height	16 mil	18 mil	ASTM D 7466	Every 2 nd Roll ⁽¹⁾
Density (g/cc) min.	0.940	0.940	ASTM D 1505/ D 792	200,000 lb
Tensile Properties (min. avg.)⁽²⁾				
Yield Strength (lb/in)	126	168	D 6993 Type IV	20,000 lb
Break strength (lb/in)	90	120		
Yield Elongation (%)	12%	12%		
Break Elongation (%)	100%	710%		
Tear Resistance (lbs) (min. ave)	42	56	D 1004	45,000 lb
Puncture Resistance (lbs) (min. ave)	90	120	D 4833	45,000 lb
Stress Crack Resistance ⁽³⁾	500 hr	500 hr	D 5397	Per GRI GM-10
Carbon Black Content (%)	2.0-3.0	2.0-3.0	D 4218	20,000 lb
Carbon Black Dispersion ⁽⁵⁾	Note 5	Note 5	D 5596	45,000 lb
Oxidative Induction Time (OIT)				
a. Std OIT, or	100 min	100 min	D 3895	200,000 lb
b. High Pressure (HP) OIT	400 min	400 min	D 5885	
Oven Aging at 85°C (min. avg.) ^{(6),(7)}			D 5721	Per Each Formulation
a. Std OIT (% ret. after 90 days) min. avg. or;	55%	55%	D 3895	
b. HP OIT (% ret. after 90 days) min. avg.	80%	80%	D 5885	
UV Resistance (min avg.) ⁽⁸⁾			D 7238	Per Each Formulation
a. Std. OIT (min. avg.), or	N.R.	N.R.	D 3895	
b. HP OIT (min. avg.) (% ret. after 1600 hrs) ⁽⁹⁾	50%	50%	D 5885	

*MQC = Manufacturing Quality Control

Notes:

1. Alternate measurement side for double sided textured sheet.
2. Machine direction and cross machine direction average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gage length of 33 mm. Break elongation is calculated using a gage length of 50 mm.
3. 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 sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the Manufacturers mean value via MQC testing.
4. Other methods such as D 1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
5. Carbon Black Dispersion (only near spherical agglomerates) for 10 different views: 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 to evaluate the antioxidant content.
7. Evaluate samples at thirty (30) and sixty (60) days and compare with the ninety (90) day response.
8. The condition of the test shall be a twenty (20) hour UV cycle at 75 degrees C followed by a four (4) hour condensation cycle at 60 degrees C.
9. UV Resistance is based on percent retained values regardless of the original HP-OIT value.

D. Seam Properties: The finished seams shall meet or exceed the values specified in the following table.

Table 02775-2: HDPE Geomembrane Seam Properties Wedge and Extrusion Welds (per GRI-GM19a)

Property	Test Value for 60 mil HDPE	Test Value for 80 mil HDPE	Test Method	MQC Testing Frequency
Seam Shear Strength lb/in	120	160	ASTM D6392	500 LF
Shear elongation at break %	50	50		500 LF
Seam Peel Strength (lb/in)	91 for hot wedge 78 for extrusion	121 for hot wedge 104 for extrusion		500 LF
Peel separation %	25	25		500 LF

Notes:

1. Seam tests for peel and shear must fail in the Film Tear Bond mode. This is a failure in the ductile mode of one of the bonded sheets by tearing or breaking prior to complete separation of the bonded area. Failures in Non-FTB mode are allowed if the failure is classified as "AD-BRK" and the strength at failure exceeds the listed value.
2. Where applicable, both tracks of a double hot wedge seam shall be tested for peel adhesion.
3. Value listed for shear and peel strengths are for 4 out of 5 test specimens, the 5th specimen can be as low as 80 percent of the listed value.

E. Stainless steel clamps shall be used to fasten pipe to the polyethylene pipe boot (if any) as shown on the Drawings. The stainless steel clamps shall be approved by the Engineer prior to their installation.

2.2 Seaming and Test Equipment

A. Seaming:

1. Approved field seaming processes are hot shoe double fusion welding and extrusion welding, when approved by the Engineer. Use double fusion welding as primary method of seaming adjacent field panels.
2. The Geomembrane Installation Contractor shall maintain on-site a minimum of two spare operable seaming apparatuses.
3. Seaming equipment shall not damage the geomembrane.
4. The Geomembrane Installation Contractor may use a hot air device ("Leister") to temporarily bond geomembrane panels that are to be extrusion welded.
5. The Geomembrane Installation Contractor shall use extrusion welding apparatus equipped with gauges giving temperature of preheat and extrudate at nozzle of apparatus.

6. Welding rods or beads used for extrusion welding shall have the same physical properties as that used for the resin used in the manufacture of the type of geomembrane that is being installed for this project.
 7. The Geomembrane Installation Contractor shall use fusion welding apparatus which are self-propelled devices equipped with a gauge indicating temperature of heating element, and a gauge indicating the speed of the welding apparatus.
- B. Vacuum Testing (for extrusion seam only)
1. The equipment shall consist of the following:
 - a. Vacuum box assembly consisting of a rigid housing, transparent viewing window, soft neoprene gasket attached to bottom of housing or port hole and valve assembly, and vacuum gauge.
 - b. Pump assembly equipped with pressure controller and pipe connections.
 - c. Rubber pressure/vacuum hose with fittings and connections.
 - d. Bucket of soapy solution.
 - e. Wide paint brush, or other means of applying soapy solution.
- C. Air Pressure Testing (for double fusion seam only)
- a. The equipment shall consist of the following:
 - b. Air pump (manual or motor driven), equipped with a pressure gauge, capable of generating, sustaining, and measuring pressure between 25 and 30 pounds per square inch (psi) and mounted on a cushion to protect geomembrane.
 - c. Rubber hose with fittings and connections.
 - d. Sharp hollow needle, or other approved pressure feed device.
 - e. An air pressure monitoring device.

3.0 EXECUTION

3.1 Subgrade

- A. The Geomembrane Installation Contractor, on a daily basis, shall certify in writing that the surface on which the geomembrane shall be installed is acceptable. It shall be the Geomembrane Installation Contractor's responsibility to maintain and protect the subgrade in the condition that was originally accepted, prior to geosynthetic deployment until accepted by the Owner and Engineer.

3.2 Acceptance

- A. The Geomembrane Installation Contractor shall retain all Ownership and responsibility for the geomembrane until final acceptance.
- B. The geomembrane shall be accepted by the Owner and Engineer when all of the following conditions are met:
 1. Installation is finished.
 2. Verification of the adequacy of all seams and repairs, including associated testing, is complete.
 3. Certification, including QC documentation is provided by the Geomembrane Installation Contractor to the Engineer.
 4. Recommended acceptance by the Engineer.

3.3 Anchor Trench

- A. The anchor trenches shall be excavated to the lines, grade, and width shown on the Drawings, prior to geosynthetic placement. The Engineer shall verify that the anchor trench has been constructed according to the Drawings.
- B. Slightly rounded corners shall be provided in the trench where the geomembrane adjoins the trench so as to avoid sharp bends in the geomembrane.
- C. The anchor trench shall be backfilled and compacted in accordance with Section 02223 and as approved by the Engineer. Anchor Trench Backfill material shall be placed in 12-inch thick loose lifts and compacted by wheel rolling with light, rubber-tired or other light compaction equipment, as approved by the Engineer.
- D. Care shall be taken when backfilling the trenches to prevent any damage to the geomembrane. At no time shall construction equipment come into direct contact with the geomembrane. If damage occurs, it shall be repaired by the Geomembrane Installation Contractor prior to the completion of backfilling, at no additional cost to the Owner.
- E. Extend geomembrane into the anchor trench as shown in the Drawings. The geomembrane shall be seamed along its entire length within the anchor trench.

3.4 Protection

- A. The Geomembrane Installation Contractor shall be responsible for the following:
 - 1. Do not use equipment or tools which may damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.
 - 2. Ensure prepared surface underlying geomembrane has not deteriorated since previous acceptance, and remains acceptable until acceptance by the Owner, as detailed in Article 3.2 of this Section.
 - 3. Keep any geotextile elements immediately underlying the geomembrane clean and free of debris.
 - 4. Personnel shall not be permitted to smoke or wear damaging shoes while working on geomembrane.
 - 5. Unroll panels in a manner which prevents scratches or crimps in geomembrane and does not damage supporting soil.
 - 6. Place panels in a manner that prevents wrinkles (especially differential wrinkles between adjacent panels).
 - 7. Prevent wind uplift and damage to geomembrane subgrade by providing temporary and permanent loading and/or anchoring that shall not damage geomembrane.
 - 8. Prevent bridging of installed geomembrane by providing adequate slack.
 - 9. Minimize direct contact of equipment and personnel with geomembrane.
 - 10. Protect geomembrane in areas where excessive traffic is expected with geotextile, extra geomembrane, or other materials acceptable to the Engineer.

3.5 Field Panel Development

- A. The Geomembrane Installation Contractor shall install field panels at locations indicated on the Geomembrane Installation Contractor's layout plan, as approved by the Engineer.
- B. The Geomembrane Installation Contractor shall replace damaged (i.e., torn, twisted, or crimped) field panels, or portions thereof, at no cost to the Owner. The Geomembrane Installation Contractor shall repair less serious damage according to Article 3.10 of this Section, at no cost to the Owner. The Engineer shall determine if material is to be repaired or replaced.
- C. The Geomembrane Installation Contractor shall remove damaged panels, portions of damaged panels, and other geomembrane scrap.

- D. Geomembrane Installation Contractor shall not deploy more geomembrane field panels in one day than can be seamed during the day of deployment.
- E. Geomembrane deployment shall proceed between ambient temperatures of 14° F to 102° F. Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, rain, dew) or in the presence of excessive winds, as determined by the Engineer.
- F. Following the installation of the geomembrane, an examination of the entire surface shall be conducted to detect potentially harmful objects. Any such objects shall be removed and the geomembrane repaired by the Geomembrane Installation Contractor, at no cost to the Owner.

3.6 Factory Seams

- A. The Engineer may require the Geomembrane Installation Contractor to test up to as much as 20 percent of factory fusion welds (non-destructive air pressure test) in the field to verify factory test results. Additional testing at Geomembrane Installation Contractor's expense shall be required if failed tests are obtained in the field.

3.7 Field Seams

A. Seam Layout

- 1. Seams shall be oriented parallel to the line of maximum slope, i.e., oriented down, not across the slope. In corners and odd-shaped geometric locations, the number of field seams shall be minimized.
- 2. No horizontal or base T-seam or tie-in seams shall be closer than 5 feet from the toe or crest of the slope. Seams shall be aligned to prevent wrinkles and "fish mouths". If a fish mouth or wrinkle is found, it shall be relieved and capped.
- 3. The previous phase geomembrane shall be cut adjacent to the existing anchor trench and double fusion welded to the new geomembrane in accordance with the Design Drawings.
- 4. Panels of geomembrane shall have sufficient overlap provided to allow peel tests to be performed on the seam.

B. Seaming Method

- 1. The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.
- 2. The Geomembrane Installation Contractor shall use double fusion welding as primary method of seaming adjacent field panels.
 - a. For cross seam tees associated with fusion welding, the Geomembrane Installation Contractor shall patch panel intersections consisting of three or more panels and extrusion weld to a minimum distance of 4 inches on each side of patch. The edge of the sheet shall be ground to a 45° angle prior to welding.
- b. Place a protective layer, e.g., insulating plate or fabric, beneath hot welding apparatus after usage.
- c. When subgrade conditions dictate, use a moveable protective layer 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.
- d. Remove seaming sheets and excess geomembrane trimmed to provide required overlap.
 - 3. Use conventional extrusion welding as a secondary method for seaming between adjacent panels and as a primary method of welding for detail and repair work.
 - a. Purge heat-degraded extrudate from barrel of extruder under the following conditions:
 - i. Prior to beginning a seam.
 - ii. Whenever extruder has been inactive.

- b. Place a smooth insulating plate or fabric beneath hot welding apparatus after usage
 - i. Use clean and dry welding rods or extrudate pellets.
 - ii. Complete grinding process without damaging geomembrane according to Manufacturer's instructions no more than one hour prior to seaming operations.
 - iii. Prevent exposed grinding marks adjacent to an extrusion weld. Do not extend exposed grinding marks more than 1/4 inch from seam area. The Engineer may request that any and all abraded areas be covered with extrudate.
 - iv. Extrusion weld all cross seam tees to a minimum distance of 4 inches on each side of the tee.
 - v. For extrusion welds, the edge of the top sheet shall be beveled by grinding the edge of the sheet to approximately a 45 degree angle. Extrusion welds cannot be placed on previous extrusion welds.

C. Seaming Procedures

1. General Seaming Procedures

- a. Areas to be seamed shall be cleaned and free of moisture, debris, or any marking on the geomembrane.
- b. Use a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support if required.
- c. Cut fish mouths or wrinkles at the seam overlap along the ridge of the wrinkle in order to achieve a flat overlap. The cut fish mouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions.
- d. Extend seaming to the outside edge of panels placed in the anchor trench.
- e. Do not field seam without the Seaming Supervisor present.

D. Field Trial Seams

- 1. Trial seams shall be conducted at the beginning of each seaming period and within 30 minutes of commencement of seaming, at the Engineer's discretion, and immediately following any work stoppage (i.e., lunch, weather conditions, etc.) of 30 minutes or more for each seaming apparatus used that day. Each Seamer shall make at least one trial seam each day.
- 2. Testing shall include visual observation of a trial seam on the geomembrane material. The Geomembrane Installation Contractor shall mark the trial seam with date, ambient air temperature, welding machine number, welding technician identification, and machine temperature and speed. For extrusion welding, the Geomembrane Installation Contractor shall include the nozzle and extrusion settings and welding technician identification. The remainder of trial seam should be cut in two pieces; one to be retained in the Owner's archive; and one to be retained by the Geomembrane Installation Contractor.
- 3. All trial seams shall be made at a location selected by the Engineer in the area of the seaming and in contact with the subgrade. The trial seam samples shall be a minimum of 5 feet long for fusion seaming and a minimum of 5 feet long for extrusion seaming, with the seam centered lengthwise. Specimens one inch wide shall be cut from opposite ends of the test seam by the Geomembrane Installation Contractor. The Geomembrane Installation Contractor shall use a tensiometer to test these specimens for shear and peel. Both inside and outside tracks of fusion welds shall be tested for peel. For both fusion and extrusion welds, two coupons shall be tested for peel and one coupon for shear. The tensiometer shall have a grip separation of 4 inches plus the width of the seam. The seam is to be centered between the clamps. These tests shall not fail according to the criteria in Article 2.1 of this Section. A break through the weld or at the weld/sheet interface shall be considered a failure in both shear and peel strength tests unless the weld strength exceeds the minimum strength, as discussed in Article 3.9 of this Section. If a trial seam fails to meet field seam

- Specifications, the seaming apparatus and/or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.
4. The Geomembrane Installation Contractor shall mark the test weld with date, ambient temperature, welding machine number, welding technician identification, machine temperature and speed. For extrusion welding, the Geomembrane Installation Contractor shall record the nozzle and extrusion settings.
 5. The Geomembrane Installation Contractor shall cut remainder of successful trial seams into two pieces, one to be retained in the Owner's archives and one to be retained by Geomembrane Installation Contractor

3.8 Non-Destructive Testing

- A. The Geomembrane Installation Contractor shall non-destructively test all field seams over their full length. All test equipment shall be furnished by the Geomembrane Installation Contractor.
- B. The following vacuum box procedures are applicable to extrusion seaming and shall be followed by the Geomembrane Installation Contractor:
 1. Clean the vacuum box window, gasket surfaces and check for leaks.
 2. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi.
 3. Wet a strip of geomembrane the approximate dimensions of the vacuum box with the soapy solution.
 4. Place the box over the wetted area and compress.
 5. Close the bleed valve and open the vacuum valve.
 6. Ensure that a leak-tight seal is created.
 7. For a period of not less than 10 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
 8. If no bubbles appear after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches overlap and repeat the process.
 9. All areas where soap bubbles appear shall be marked and repaired and then retested.
 10. Test locations, documentation number, date and tester shall be indicated with an indelible marker on the geomembrane for each repair or seam section. The color code for indelible markers is to be determined at the pre-construction meetings, and strictly adhered to.
- C. The following nondestructive test procedures are applicable to fusion seaming and shall be followed by the Geomembrane Installation Contractor:
 1. Seal one end of the seam to be tested.
 2. Insert needle or other approved pressure feed device through the sealed end of the channel created by the double wedge fusion weld.
 3. Energize the air pump to verify the unobstructed passage of air through the channel.
 4. Seal the other end of the channel.
 5. Energize the air pump to the pressure of approximately 30 psi, close valve, and sustain pressure for approximately 5 minutes.
 6. If loss of pressure exceeds 3 psi, or pressure does not stabilize, locate faulty area, repair and retest.
 7. Remove needle or other approved pressure feed device.
 8. Repair pressure test locations as described in Article 3.10 of this Section.

9. Beginning and ending pressures and times, test locations, documentation number, date and tester shall be indicated with an indelible marker on the liner at each test interval location.
- D. The following procedures shall apply to locations where seams cannot be non-destructively tested, as determined by the Engineer:
 1. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.
 2. If the seam cannot be tested prior to final installation, the seaming operations shall be observed by the Engineer for uniformity and completeness.
- E. In the event that seam continuity cannot be demonstrated for a non-destructive test of a fusion seam as outlined above, the Geomembrane Installation Contractor shall perform the non-destructive testing over smaller areas as a means of defining the questionable area, and shall:
 1. Extrusion weld the outside edge of the questionable seam area and vacuum box test the extrusion weld, or
 2. Cap the questionable area and vacuum test the cap.

3.9 Destructive Testing

- A. The Geomembrane Installation Contractor shall test a minimum of one destructive test sample per 500 feet of seam length per welding machine from a location specified by the Engineer. The Geomembrane Installation Contractor shall not be informed in advance of the sample location. The samples shall be taken centered over the seam and prioritized as follows:
 1. All areas identified as suspect during seaming, non-destructive testing/monitoring, and in unusual working conditions.
 2. A minimum of one sample for each geomembrane seamer.
 3. A minimum of one sample every 500 feet of seaming.
- B. Samples shall be cut by the Geomembrane Installation Contractor as the seaming progresses. Sampling locations shall be determined by the Engineer. The Engineer must witness the obtainment of all destructive test samples by the Geomembrane Installation Contractor. All samples shall be marked with their seam number, date, welding machine number, welding technician identification, extruder and nozzle/wedge temperature, and ambient air temperature. The Geomembrane Installation Contractor shall document the date, time, roll and seam number, ambient temperature, and pass or fail description. All holes in the geomembrane resulting from obtaining the seam samples shall be immediately repaired. All patches shall be vacuum tested.
- C. The samples shall be a minimum 12 inches wide by 24 inches long with the seam centered lengthwise. The sample shall be cut into two equal length pieces, half to be given to the Owner for archiving and the other kept by the Geomembrane Installation Contractor for testing.
- D. Geomembrane Installation Contractor shall cut and test ten (10) one-inch (1") wide specimens from his sample. All testing shall be conducted at room temperature (60°F to 80°F). The Geomembrane Installation Contractor shall test five (5) specimens for seam shear strength and five (5) for peel strength. Both inside and outside tracks of fusion seams shall be tested for peel strength. To be acceptable, four (4) out of the five (5) specimens must pass according to criteria established in Article 2.1 of this Section. Any specimen that fails through the weld or at the weld/sheet interface shall be considered a failure, unless the weld strength exceeds the minimum strength specified in Table 02775-2, as discussed Article 2.1. The tensiometer shall have a grip separation of 4 inches plus the width of the seam. The seam is to be centered between the clamps.
- E. The Engineer must witness the testing of all destructive samples. Destructive tests shall be performed within two (2) days of the samples being obtained.
- F. Failing tests shall be subjected to additional testing until a passing area is found. A passing area is defined as a seam(s) bounded at each end by a passing destructive test. Seams shall be tracked in each direction until a passing destructive test is found or until a previous passing destructive test is

reached. Seams shall be tracked according to the welding apparatus and the machine operator. The following procedures shall apply whenever a sample fails the field destructive test:

1. The Geomembrane Installation Contractor can retrace the welding path to an intermediate location (at a minimum of 10 feet from the location of the failed test), at the Engineer's discretion, and take a small sample for an additional field test. If this test passes, then the seam shall be cap stripped between that location and the original failed location. If the test fails, the process shall be repeated.
 2. Over the length of seam failure, the Geomembrane Installation Contractor shall either cut out the old seam, reposition the panel and reseam, or add a cap strip, as required by the Engineer.
 3. After reseaming or placement of the cap strip, additional destructive field test(s) shall be taken within the reseamed area. The reseamed sample shall be found acceptable if test results are approved by the Engineer. If test results are not acceptable, this process shall be repeated until the reseamed length is judged satisfactory by Engineer.
 4. Samples taken as the result of failed tests do not count toward the total number of destructive tests required.
- G. The Geomembrane Installation Contractor shall document all actions taken in conjunction with destructive test failures, with the Engineer providing Quality Assurance documentation.
- H. Cap strips shall be non-destructively tested as described in Article 3.8 of this Section.

3.10 Defects and Repairs

- A. All seams and non-seam areas of the geomembrane shall be observed by the Engineer for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of observation. The geomembrane surface shall be brushed, blown, or washed by the Geomembrane Installation Contractor if the amount of dust or mud inhibits inspection. The Engineer shall determine if cleaning of the geomembrane is needed to facilitate observation.
- B. Each suspect location in seam and non-seam areas shall be non-destructively tested as determined appropriate by the Engineer, in the presence of the Engineer. Each location that fails the non-destructive testing shall be marked by the Geomembrane Installation Contractor, and repaired accordingly.
- C. Repair Procedures
1. Defective seams shall be reconstructed as described in these Specifications.
 2. Small holes shall be repaired by abrading the sheet surface and welding an extrusion bead. If the hole is larger than ¼-inch in diameter it shall be patched.
 3. Tears shall be repaired by patching. Where the tear is on a slope or an area of stress and has a sharp end it must be rounded prior to patching.
 4. Blisters, large holes, undispersed raw materials, and contamination by foreign matter shall be repaired by patches.
 5. Surface of geomembrane that are to be patched shall be abraded and cleaned no more than 15 minutes prior to the repair. No more than 10 percent of the thickness shall be removed.
- D. Patches shall be round or oval in shape, and extend a minimum of 6 inches beyond the edge of defects. All patches shall be of the same compound and thickness as the geomembrane specified. All patches shall have their top edge beveled to an approximately 45° angle with an angle grinder prior to placement of the patch. Patches shall be applied using approved methods only.
- E. The extrusion welding process shall restart by grinding the existing seam and rewelding a new seam. Welding shall commence where the grinding started and must overlap the previous seam by at least 2 inches. Reseaming over an existing seam without regrinding shall not be permitted.
- F. Each repair shall be non-destructively tested, except when the Engineer requires a destructive seam sample obtained from a repaired seam. Repairs that pass the destructive test shall be taken as an

indication of an adequate repair. Failed tests indicate that the repair shall be repeated and retested until passing test results are achieved.

- G. Recording the Results: Daily documentation of all non-destructive and destructive testing shall be provided to the Engineer. This documentation shall identify all seams that initially failed the test and include evidence that these seams were repaired and successfully retested.

3.11 Conformance Testing

- A. During manufacturing of the geomembrane, the Engineer shall be present to observe manufacturing of geomembrane and shall ensure that samples are obtained and forwarded to the Geomembrane Quality Assurance Testing Laboratory for testing to ensure conformance with the Specifications.
- B. Samples shall be taken across the entire width of the roll and shall not include the first 3 feet. Unless otherwise stated, samples shall be 3 feet long by the width of the roll. The Engineer shall mark the machine direction on the samples with an arrow. Unless otherwise stated, samples shall be taken at a frequency of no less than one per 2,000,000 square feet or one per lot, whichever is less. As a minimum, the following tests shall be performed to verify conformance to the design Specifications with minimum values specified in Article 2.1 of this Section:

Table 02775-3: Minimum Conformance Testing

PROPERTY	TEST METHOD	FREQUENCY
Thickness (mils)	ASTM D 5199	2,000,000 sq. ft or Minimum 1 test per resin lot, whichever is greater (each test)
Compound Density (g/cc)	ASTM D 1505	
Tensile Strength (Both yield and ultimate strength and elongation, as specified)	ASTM D 6693	
Carbon Black Content (%)	ASTM D 1603	

- C. Manufacturer shall provide current certification for Oxidation Induction Time (OIT) for each formulation and shall meet the minimum test values presented in Article 2.1 of this Section.

3.12 Placement of Soil or Granular Materials

- A. All soil materials located on top of a geomembrane shall be placed in such a manner as to ensure:
 1. The geomembrane and any underlying geotextile is not damaged.
 2. Minimal slippage of the geomembrane on underlying layers occurs.
 3. Minimal movement and wrinkling or folding of the underlying geosynthetics layer(s) occurs.

No excess tensile stresses shall occur in the geomembrane, such as by earth moving equipment making sudden starts, stops, turns. The allowable ground pressure for equipment shall be prescribed by the Engineer for the material type and layer thickness.

3.13 Warranty

- A. Without limiting the provisions of the Contract, the Geomembrane Installation Contractor shall warrant the Work to the Owner in accordance with the following:
- B. The geomembrane supplied is suitable for the environmental conditions at the site and the service conditions as described in this Specification.
- C. The geomembrane supplied meets or exceeds all published Specifications as referenced by the Specification.
- D. The geomembrane is free of defects in materials and workmanship.
- E. The Geomembrane Installation Contractor shall repair or replace all defects in the material detected on-site, including uncovering and recovering the work, in compliance with the Specifications.

- F. The Geomembrane Installation Contractor shall repair any detected leaks in any seams (Manufactured or field joined), including uncovering and recovering the work, in compliance with the Specifications.
- G. All workmanship furnished by the Geomembrane Installation Contractor under this Specification shall be guaranteed by the Geomembrane Installation Contractor against failure due to improper installation for a period of not less than two (2) years. All permanent materials furnished by the Geomembrane Installation Contractor under this Specification shall be guaranteed by the Geomembrane Installation Contractor and the geomembrane manufacturer for a period of not less than twenty (20) years.
- H. Upon written notice that the material fails to meet the original intent of the design, or of failure of guaranteed materials or workmanship during the guarantee period, the Geomembrane Installation Contractor shall promptly furnish and install new materials and/or furnish the workmanship necessary to correct the failure at the expense of the Geomembrane Installation Contractor. The Geomembrane Installation Contractor shall bear all costs for labor and materials associated with repair of guaranteed work.

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

**SECTION 03110
CONCRETE FORMWORK**

1.0 GENERAL

1.1 Section Includes

- A. Related Sections
- B. Products
- C. Execution

1.2 Related Sections

- A. Section 03300 – Cast-in-place Concrete

1.3 Products

1.3.1 Materials

- A. Forms shall be 5-ply, 3/4-inch, waterproof, exterior type plywood, free of loose knots, splinters, or other defects. The face adjacent to concrete shall be Grade B or better. Forms may be fiberboard, Fed. Spec. LLL-B-810, Type II, tempered, waterproof, screenback, concrete form hardboard.
- B. Form ties shall be of the removable end, permanently embedded body type. Cones shall be provided on the outer ends of each tie and the permanently embedded portion shall be at least one inch back from the concrete face. Form ties for water bearing walls, shall be provided with water seal washers located on the permanently embedded portions of the tie at the approximate center of the wall. The cone ends of the form ties shall have a diameter of 1 inch and shall be constructed so that they are easily removed or broken off without damage to the concrete. Form ties may be Burke BA Penta-Tie with a water seal washer, or an equivalent approved by the Engineer.
- C. Form release or coating shall be nontoxic after 30 days and non-staining, such as Nox-Crete "Form Coating" or Protex "Pro-Cote", or Richmond "Rich-Cote".

2.0 EXECUTION

2.1 Installation

- A. The Contractor shall be responsible for the location and placement of all sleeves, pipe fittings, anchors, ties, and inserts, and shall make certain that offsets, recesses, openings, and block-outs are in place in the forms before concrete is placed.
- B. Form release agents shall be applied at no more than the manufacturer's recommended application rates.
- C. Where forms are placed above geomembrane liner, no anchoring of the forms will be allowed that damage the geomembrane liner. Use of sandbags, earth forms, or other form of anchoring/bracing maybe employed and approved by the Engineer prior to construction of formwork.
- D. Horizontal joints shall be level and continuous. Vertical joints shall be plumb.
- E. Forms shall be sufficiently tight and rigid to prevent leakage of concrete.
- F. Forms shall be properly tied, braced, shored, and supported to insure stability against pressure from any source and without deflection or failure of any component or part.
- G. Forms shall be removed without damage to the concrete, chamfers, inserts, anchors, geomembrane liners, and piping.
- H. Forms shall not be removed until concrete has sufficiently hardened. Unless otherwise approved by the Engineer, forms shall not be removed within five (5) days of placement.

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

SECTION 03220 REINFORCING STEEL

1.0 GENERAL

1.1 Section Includes

- A. Related Sections
- B. References
- C. Submittals
- D. Quality Control
- E. Delivery, Storage, and Handling
- F. Products
- G. Execution

1.2 Related Sections

- A. Section 03110 – Concrete Formwork
- B. Section 03300 – Cast-in-place Concrete

1.3 References

- A. ACI 301 - Specifications for Structural Concrete
- B. ACI 315 - Details and Detailing of Concrete Reinforcement
- C. ACI 318 – Building Code Requirements for Structural Concrete
- D. ASTM A 82/A82M- Steel Wire, Plain, for Concrete Reinforcement
- E. ASTM A 184/A 184M - Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
- F. ASTM A 416/A 416M - Steel Strand, Uncoated Seven-Wire for Pre-stressed Concrete
- G. ASTM A 496/A 496M - Steel Wire, Deformed, for Concrete Reinforcement
- H. ASTM A 497/A 497M - Steel Welded Wire Reinforcement, Deformed, for Concrete
- I. ASTM A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- J. ASTM A 704/A 704M-06 (R2011) - Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
- K. ASTM A 775/A 775M-07B - Epoxy-Coated Reinforcing Steel Bars
- L. ASTM A 1064/A 1064M-14 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
- M. AWS D1.4 - Structural Welding Code - Reinforcing Steel
- N. IBC 2018 - International Building Code 2018

1.4 Submittals

- A. Detail reinforcement in accordance with ACI 301, ACI 315 and ACI 318.
- B. Provide complete bar lists together with location and setting drawings with sufficient plans, elevations, sections and details to clearly show the positioning and number of bars. Identify bar lists with drawings. Identify by mark number of each bar. Show relationship of reinforcement with construction joints, control joints, expansion joints and embedded parts.
- C. Ensure that embedded parts not shown on the Drawings, but required for the Work, are shown on the reinforcing setting drawings when submitted to the Owner or His Representative for review.

- D. Do not prepare work until the bar lists and drawings covering that work have been reviewed and approved by the Owner or his Representative. Submit bar list well in advance of required fabrication to avoid construction delay.
- E. Improperly prepared bar lists and drawings are subject to rejection on that basis alone without further review. Redraw and resubmit.

1.5 Quality Control

- A. Personnel Qualifications
 - 1. Contractor shall employ personnel skilled and experienced in the fabrication and installation of reinforcement.
- B. Tolerances
 - 1. Fabricate and install concrete reinforcement in accordance with ACI 301 except as required by the Drawings.

1.6 Delivery, Storage, and Handling

- A. In addition to the requirements of ACI 301:
 - 1. Store and handle reinforcing steel so as not to alter the shape and dimensions.
 - 2. Prevent contamination of the reinforcing steel.
 - 3. Do not dump materials when unloading or handling.

2.0 PRODUCTS

2.1 Materials

- A. Reinforcing steel and rock dowels
 - 1. In accordance with ASTM A615 GRADE 60.
- B. Welded wire fabric:
 - 1. In accordance with ASTM A1064.
- C. Headed Studs:
 - 1. Headed studs shall be mild steel studs from Nelson Stud Welding conforming to the requirement of ASTM A108.
- D. Support of reinforcement
 - 1. Supports, spacers and chairs:
 - a. Precast concrete blocks, for bottom bars in ground supported slabs and foundations only.
 - b. Plastic of approved design and manufacture.
 - c. Steel of approved design and manufacture with rust-proof finish where any part extends to the surface of the concrete.

2.2 Fabrication

- A. Reinforcing steel
 - 1. Fabricate reinforcing steel in accordance with ACI 301 to the dimensions shown on the bar lists and shop drawings.
 - 2. Do not bend or straighten reinforcing bars in a manner, which might damage the bars or reduce the cross-section. Do not use bars with kinks or sharp bends.
 - 3. Identify each bar, with the same code used for it in the bar lists and shop drawings.
 - 4. Verify foundation elevations at the Site before cutting and bending reinforcing steel.

3.0 EXECUTION

3.1 Examination

- A. Prior to commencing installation, thoroughly examine other work upon which the Work of this Section is dependent. Report any deficiencies discovered and propose adjustments to the Owner or His Representative and obtain written authorization before proceeding.
- B. Check that forms are in satisfactory condition for the Work of this Section to proceed.

3.2 Installation

- A. Install reinforcement in accordance with ACI 301, ACI 315, ACI 318 and the following:
- B. Secure crossing bars at every intersection (unless otherwise noted on the Drawing) by using black tie-wire of not less than No. 16 gage.
- C. Ensure concrete cover, placing and maintaining position of reinforcement is in accordance with ACI 301, ACI 315, ACI 318 and as shown on the Drawings.
- D. Install tension and compression splices for reinforcing steel in accordance with ACI 318 and as shown on the Drawings.
- E. At running joints, place starter bars or dowels equivalent in size and spacing to the continuing reinforcing of the member.
- F. At wall corners, provide embedment and splice all horizontal bars according to code requirements.
- G. Welding of Reinforcing Steel:
 - 1. Obtain approval of the Owner or His Representative before welding or tack welding reinforcement. Rebar may only be welded along the longitudinal axis only with the approval of the Owner or His Representative.
 - 2. Perform welding in accordance with AWS D1.4.
 - 3. Weld structural reinforcement in accordance with the requirements of ACI 301.
 - 4. Do not weld reinforcing steel closer than 2 inches from the beginning of a bend and within a bend.
- H. Openings in Concrete
 - 1. Provide additional reinforcing bars around opening as shown on the Drawings.
 - 2. Where opening of 18 inches diameter or square and larger occur and interrupt more than two reinforcing bars, add reinforcing bars equivalent to the interrupted reinforcing bars at each side of the opening.

END OF SECTION

**SECTION 03300
CAST-IN-PLACE CONCRETE**

1.0 GENERAL

1.1 Section Includes

- A. Submittals
- B. Materials
- C. Mixes
- D. Curing Compounds
- E. Installation
- F. Quality Control

1.2 Relation Sections

- A. Section 01010 – Summary of Work
- B. Section 01300 – Submittals
- C. Section 02710 – Gravity Piping
- D. Section 11207 – Parshall Flumes

1.3 References

- A. American Concrete Institute (ACI)
 - 1. ACI 304R - Guide for Measuring, Mixing, Transporting and Placing Concrete
 - 2. ACI 305R - Hot Weather Concreting
 - 3. ACI 306R - Cold Weather Concreting
 - 4. ACI 318 - Building Code Requirements for Structural Concrete
- B. American Society of Testing and Materials (ASTM)
 - 1. ASTM C 33 – Standard Specification for Concrete Aggregates
 - 2. ASTM C 39 – Standard Specification for Compressive Strength of Cylindrical Concrete Specimens
 - 3. ASTM C 94 – Standard Specification for Ready-Mix Concrete
 - 4. ASTM C 143 – Standard Test Method for Slump of Hydraulic-Cement Concrete
 - 5. ASTM C 150 – Standard Specification for Portland Cement
 - 6. ASTM C 231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
 - 7. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete
 - 8. ASTM C 309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 - 9. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete
 - 10. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for use in Concrete
- C. International Building Code
 - 1. IBC 2018 – International Building Code 2018

1.4 Submittals

- A. Submit mix designs to the Engineer under provisions of Section 01300 and this section.
- B. Product Data: Mix design for each tentative mix for Lean Mix Concrete:
 - 1. Slump on which design is based
 - 2. Total gallons of water per cubic yard
 - 3. Brand, type, composition, and quantity of cement
 - 4. Specific gravity and gradation of each aggregate
 - 5. Ration of fine to total aggregates
 - 6. Weight (surface dry) of each aggregate per cubic yard
 - 7. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture
 - 8. Air content
 - 9. Compressive strength based on 7 day and 28-day compression tests
 - 10. Time of initial set

2.0 PRODUCTS

2.1 Materials

- A. Portland cement, ASTM C 150, Type II.
- B. Coarse aggregate, ASTM C 33, except that clay and shale particles shall not exceed on percent.
- C. Fine aggregate, ASTM C 33, washed natural sand.

2.2 Mixes

- A. Mix Designs
 - 1. Concrete mix design shall be designed by an independent testing laboratory.
- B. Cast-in-Place Concrete, reinforced
 - 1. Cast-in-Place Concrete shall have a minimum 28-day compressive strength of 4,000 psi.
 - 2. Maximum aggregate size of ¾-inch.
 - 3. Placement slump of 4 inches, with tolerances of plus 1-inch or minus 1-inch.
 - 4. Design mix shall assure 4 to 6 percent air entrainment.
- C. Lean Mix Concrete, unreinforced
 - 1. Lean Concrete shall have a minimum 28-day compressive strength of 2,000 psi.
 - 2. Maximum aggregate size of 1-½ inches.
 - 3. Placement slump of 4 inches, with tolerances of plus 1-inch or minus 1-inch.

2.3 Curing Compounds

- A. Concrete curing compounds shall be a clear compound conforming to ASTM C 309, Type 1-D, Class A and B, such as "RES-X" by Burke, or an equivalent approved by the Engineer.

3.0 EXECUTION

3.1 Installation

- A. Ready-mix concrete shall be batched, transported, and placed in accordance with ASTM C94. Each batch delivered to the site shall be accompanied by a certified weightmaster's delivery ticket.

- B. All mixed concrete delivered to the site shall be placed within 90 minutes from the time of introduction of cement and water into the mix.
- C. No water shall be added after leaving the batch plant without the approval of the Engineer.
- D. Placement of concrete, once started, shall be performed as a continuous operation until the scheduled pour is completed.
- E. Concrete placed under water will be placed using tremie methods. Concrete will not be allowed to free fall through water.
- F. Concrete shall not be placed during freezing weather conditions.

3.2 Schedules

- A. The Contractor shall notify the Engineer at least 48-hours before each concrete placement.

3.3 Quality Control

- A. Concrete testing will be performed by the Quality Assurance Team. Such testing shall not relieve the Contractor from providing quality control to make sure concrete is in compliance with specification.
- B. Four standard 6-inch diameter by 12-inches long test cylinders shall be prepared for every 50 cubic yards of concrete poured or for each pour, whichever is greater.
- C. Standard compression tests shall be performed to determine the compressive strength: one at 7 days, one at 14 days, and one at 28 days. The fourth cylinder shall be kept in reserve for additional testing, if necessary.
- D. Slump and air entrainment testing shall be performed at the time the cylinders are prepared.

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

**SECTION 11207
PARSHALL FLUMES**

1.0 GENERAL

1.1 Section Includes

- A. References
- B. Submittals
- C. Parshall Flumes
- D. Fabrication
- E. Handling and Storage
- F. Installation
- G. Pipe Connections
- H. Cast-in-place Concrete

1.2 Related Sections

- A. Section 02205 – Fill Materials
- B. Section 02222 – Excavating
- C. Section 02223 – Filling
- D. Section 03110 – Concrete Formwork
- E. Section 03220 – Reinforcing Steel
- F. Section 03300 – Cast-in-place Concrete

1.3 References

- A. ASTM D 638 – Standard Test Method for Tensile Properties of Plastics.
- B. ASTM D 790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulation Materials.
- C. ASTM D 1941-91(2001) – Standard Test Method for Open Channel Flow Measurement of Water with Parshall Flume
- D. ASTM D 2583 – Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol impressor.
- E. ISO 982-92 – Measurement of Liquid Flow in Open Channel – Parshall and SANIIRI Flumes.
- F. United States Department of the Interior, Bureau of Reclamation, Water Measurement Manual.

1.4 Submittals

- A. Submit the following under provisions of Section 01300.
- B. The Contractor shall provide detailed information to the Owner and Engineer for: flume, fittings, measurement attachments, and joining manufacturer's data, including type/class, method of joining, specifications, manufacturer's name, and manufacturer's certificate of compliance.
- C. Shop Drawings:
 - 1. Critical dimensions, jointing and connections, fasteners, and anchors.
 - 2. Materials of construction.
 - 3. Sizes, spacing, location of structural members, connections, attachments, openings, and fasteners.
- D. Contractor to follow Manufacturer's recommended installation instructions. Deviations from Manufacturer's installation instructions shall be approved by the Engineer.

- E. If an equivalent product is proposed, submit samples, technical data, test data, and specifications sufficient to allow evaluation by Engineer.

2.0 PRODUCTS

2.1 Parshall Flumes

- A. Flumes shall be manufactured by TRACOM, Inc. of Alpharetta, Georgia, USA, or an equivalent approved by the Engineer.
- B. Flumes shall be 2-inch Parshall type and shall be of one-piece construction
- C. Materials:
 - 1. Fiberglass reinforced plastic.
 - 2. Gloss inside surfaces, free of irregularities.
 - 3. Minimum 3/16-inch wall thickness.
 - 4. Minimum 30% glass, by weight.
 - 5. Isophthalic polyester resin.
 - 6. Removable pultruded fiberglass bracing at top of flume with T-304 stainless steel hardware.
 - 7. 2-inch (minimum) top and end stiffening flanges.
 - 8. Molded-in stiffening ribs, maximum 12-inch center-to-center spacing.
 - 9. 15 mil Isophthalic UV resistant gel coat on all surfaces, white interior, grey exterior.
 - 10. Anchor clips, pre-drilled with 3/4-inch hole, pultruded fiberglass construction
 - 11. Tensile strength (ASTM D 638) – 14,000 psi.
 - 12. Flexural strength (ASTM D 790) – 27,000 psi.
 - 13. Flexural modulus (ASTM D 790) – 1.0 million psi.
 - 14. Barcol hardness (ASTM D 2583) – 50.

2.2 Flume Attachments

- A. Ultrasonic Mounting Bracket:
 - 1. Fixed Position stainless steel.
 - 2. Horizontally and vertically adjustable stainless steel.
 - 3. 2-inch diameter NPT coupling for third-party mounting bracket, if required.

2.3 End Connections

- A. Inlet and outlet end adaptors
 - 1. 6-inch inlet and outlet pipe stubs shall be fitted with a bolt pattern to allow bolting to a 6-inch IPS flange adaptor and ANSI 150 lb. flat-faced flange.

3.0 EXECUTION

3.1 Handling and Storage

- A. Transportation of Parshall Flumes and fittings shall be the responsibility of the Contractor. The Contractor shall be liable for all damage incurred prior to and during transportation to the site.
- B. Handling, storage and care of the pipe, valves, and fittings prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damage to the material incurred prior to final acceptance by the Engineer.

- C. The Contractor shall be responsible for storage of Parshall Flumes and fittings at the site. Pipe, valves, and fittings shall be stored on clean level ground, which is free of sharp objects which could damage these materials. Stacking shall be limited to a height that shall not cause excessive deformation of the bottom flumes under anticipated temperature conditions. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitable and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

3.2 Installation

- A. Parshall Flumes shall be installed above an 80-mil HDPE geomembrane rubsheet within the Underdrain Collection Channel in accordance with the Design Drawings.
- B. Parshall Flumes shall be installed to the lines and grades shown on the Design Drawings.
- C. Parshall Flumes shall be installed plumb and the upstream floor of the Flume is level.
- D. Parshall Flumes shall be embedded in concrete. Pour concrete in maximum 6-inch lifts. Internally line and brace the flume as necessary to prevent bowing or distortion of the of the flume until concrete is cured. Concrete shall meet the specifications of Section 03300 – Cast-in-place Concrete.

3.3 Tolerances

- A. Parshall Flumes shall be installed to the lines and grades in the Design Drawings.
- B. Parshall Flumes shall be installed plumb and the upstream floor level.

3.4 Quality Control

- A. A short description of the Quality Control program shall be submitted by the Contractor with the bid to the Engineer and Owner. This description shall state the Quality Control standard to be used and as a minimum containing the following:
 - 1. An organization chart with a brief job description of Quality Control function
 - 2. A list of applicable procedures for implementation of the Quality Control program
 - 3. A general description of how each Quality Control requirement is to be fulfilled during the design, procurement, manufacture, assembly and testing
- B. During award phase, the Quality Control documentation shall be forwarded to the Engineer as specified in Section 01300. Pertinent Quality Control documentation including Quality Control manuals shall be approved by the Engineer prior to any production work commencing. A minimum of five working days shall be allowed for the Engineer's review.
- C. Upon delivery of the pipe, the Contractor shall forward the following documentation:
 - 1. All Vendor certificates and tests performed per these Specifications
 - 2. All Vendor documents verifying that inspection, control, and tests performed are in accordance with these Specifications
 - 3. Identification lists with cross references between documents and hardware/materials for traceability purposes
- D. The Engineer or Owner shall have the right to carry out audits at the Contractor's, Vendor's, and their subcontractor's facilities, to verify compliance with all aspects of the documentation included in the purchase order. For the purpose of evaluating and auditing, the Contractor, Vendor, and their subcontractors shall give free access to all facilities concerned and to all the Quality Control documents and records
- E. Applicable records may be requested by the Engineer or Owner at any time during production, these shall be forwarded to the Engineer or Owner upon request within five working days. The Contractor or Vendor shall give a written response to the Engineer or Owner for any corrective action requests and if requested, take the necessary corrective action in a timely manner.

END OF SECTION

**SECTION 17150
METERS AND INSTRUMENTATION**

1.0 GENERAL

1.1 Section Includes

- A. Prequalification
- B. Performance Requirements
- C. Design Requirements
- D. Submittals
- E. Delivery, Storage, and Handling
- F. Products
- G. Execution

1.2 Performance Requirements

- A. This Work shall include the furnishing of all labor, tools, equipment, and other items necessary for the installation meters and instrumentation as shown on the Drawings. All Work shall be performed in accordance with the lines, grades, sections, and dimensions shown on the Drawings, or as directed by the Engineer.

1.3 Design Requirements

- A. All instrumentation materials, installation methods and materials, and data collection prior to, during, and after installation shall meet the minimum requirements of Manufacturer's recommendation and the **Geotechnical Monitoring Plan for the Grassy Mountain TSF and WRD, Revision 0 prepared by Golder Associates Inc.**
- B. All instrumentation installation shall be performed by, or at the direction of, the Engineer.

1.4 Submittals

- A. Submittals detailed below shall be in accordance with Section 01300.
- B. After the Contract Award:
 - 1. Submit equipment models, operation, installation, and maintenance manuals for vibrating wire piezometers, settlement cells and gauges, readout equipment, and inclinometers. Obtain Engineer approval for all instrumentation prior to shipping to the site.
 - 2. Submit shop drawings of prefabricated instruments and materials for approval by the Engineer.
 - 3. Submit proof of qualification for installation of any instrumentation.
- C. After Installation:
 - 1. Submit installation details for all instrumentation, including boring logs, location and elevation of the piezometers, piezometer cables, riser pipes, readout stations, surface monuments, inclinometers, and underdrain flow meters.
 - 2. Submit the installation-specific operation manual developed for the vibrating wire piezometers, inclinometers, underdrain flow meters, and readout stations including calibration data for conversion of gauge readings to pressure.

2.0 PRODUCTS

2.1 Product Handling

- A. Shipping Precautions: After completion of shop assembly, factory test, and approval, instruments shall be packed and secured to provide complete protections from damage, dust and moisture.

- A. Special Instructions: Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of instrument prior to packaging and shipment.
- B. Tagging: Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment. Identification shall be prominently displayed on the outside of the package.
- C. Storage: Instruments shall not be stored outdoors. Instruments shall be stored in dry permanent shelters and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor.

2.2 Manufacturer's Services

- A. Contractor may need to furnish some or all of the manufacturer's services for the instrumentation listed in this specification:
 - 1. Perform factory bench calibration
 - 2. Oversee installation
 - 3. Verify installation of installed instrument
 - 4. Site verification of calibration

2.3 Material

- A. Vibrating Wire (VW) Piezometers
 - 1. Impoundment (PZ-TI and PZ-WI Series) and Underliner VW Piezometers (PZ-TU, PZ-WU Series)
 - a. Impoundment and Underliner VW piezometers shall have a pressure range of 0 to 100 psi with a resolution of 0.03 psi at 100 psi (Model Number VW2100-XXXX).
 - b. Signal output shall be a frequency output in the millivolt range or digits.
 - c. The filter shall be Standard: 50 micron sintered stainless steel.
 - d. VW piezometers shall be manufactured by RST Instruments, based in Maple Ridge, British Columbia, or other manufacturer approved by the Engineer.
 - 2. Embankment Foundation VW Piezometers (PZ-TF Series)
 - a. Embankment Foundation VW piezometers shall be of standard VW piezometers prefabricated in nested construction (Multi-point Piezometer Strings).
 - b. Embankment Foundation VW piezometers shall have a pressure range of 0 to 150 psi with a resolution of 0.04 psi at 150 psi (Model Number VW2100MP).
 - c. Nesting of the Embankment Foundation VW piezometers will be at the vertical intervals described in the Geotechnical Monitoring Plan, or at the direction of the Engineer.
 - d. Signal output shall be a frequency output in the millivolt range or digits.
 - e. The filter shall be Standard: 50 micron sintered stainless steel.
 - f. VW piezometers shall be manufactured by RST Instruments, based in Maple Ridge, British Columbia, or other manufacturer approved by the Engineer
- B. VW Piezometer Signal Cables
 - 1. Impoundment VW Piezometer (PZ-TI, PZ-WI Series) and Underliner (PZ-TU, PZ-WU Series) Signal Cable
 - a. Shall be standard vibrating wire signal cable (Model EL380004) manufactured by RST Instruments, based in Maple Ridge, British Columbia.

- b. Shall be with 22-gauge tinned-copper conductors and polyurethane jacket.
 - c. Signal cable shall be prefabricated to the VW piezometer during manufacturing to the specific cable length required for each instrument as shown on the Drawings and Geotechnical Monitoring Plan.
 - d. Cable conduit shall be 2-inch diameter Schedule 80 PVC pipe with flush interior glue joints.
2. Embankment Foundation VW Piezometers (PZ-TF Series)
 - a. Shall be 12 conductor, Kevlar® wire with water-blocked polyurethane jacket signal cable (Model EL380012) manufactured by RST Instruments, based in Maple Ridge, British Columbia.
 - b. Shall be with 22-gauge tinned-copper conductors and polyurethane jacket.
 - c. Signal cable shall be prefabricated to the VW piezometer during manufacturing to the specific cable length required for each instrument as shown on the Drawings and Geotechnical Monitoring Plan.
 3. Cable splicing shall be limited to areas where vertical overburden pressures are limited to less than 25 psi and as directed by the Engineer. Cable splicing kits shall be manufactured by RST Instruments, based in Maple Ridge, British Columbia and shall be compatible with the specific VW piezometer signal cables.
 4. Impoundment (PZ-TI and PZ-WI Series) and Underliner VW Piezometers (PZ-TU, PZ-WU Series) shall be placed in canvas bags supplied by the manufacturer and surrounded by No. 30 concrete sand.
- C. Readout Stations
1. Single Channel VW portable readout (model number VW2106), shall be used for all VW piezometers for instantaneous field measurements during and after installation. The readout will measure a frequency range of 400 Hz to 6000 Hz, a temperature readout range between -50 and 80 °C, with a frequency resolution of 0.01 μ s and temperature resolution of 0.1 °C.
 2. After initial installation, Data loggers and multiplexers shall be installed within each Readout Station to collect real-time measurements of all WV piezometers.
 3. Data Loggers shall be the RST FlexDAQ system and include the following:
 - a. CR6 Data Logger manufactured by Campbell Scientific, Inc. of Logan, Utah
 - b. RST Flexi-Mux Multiplexer(s) manufactured by RST Instruments.
 - c. AC or DC (solar) power supply with battery backup module
 - d. Electrical grounding if DC-powered
 - e. Lightning protection
 - f. Communication module (if required by, and at the direction of, the Owner)
 - g. Weatherproof NEMA-rated enclosure
 - h. Mounting post and hardware
 4. Each Readout Station shall be constructed such that it has the capability to read and record in real-time the following quantity of instruments:
 - a. RS-1 – Twenty-two (22) VW piezometer signal cables
 - b. RS-2 – Four (4) VW piezometer signal cables
 - c. RS-3 – Four (4) Ultrasonic transducer signal cables and dataloggers
 - d. RS-4 – Eight (8) VW piezometer signal cables
 - e. RS-5 – Six (6) VW piezometer signal cables

D. Inclinometers

1. Inclinometer casing shall be installed along the downstream dam crest of the Stages 1 through 3 main north embankments as shown on the Drawings and in accordance with the Geotechnical Monitoring Plan.
2. Inclinometer casings shall be 70-mm (2.75-inch) diameter Snap Seal type (Model ICS205 or ICS210) manufactured by RST Instruments, based in Maple Ridge, British Columbia.
3. Inclinometer casings shall be either 5-foot or 10-foot segments and constructed of non-recycled virgin ABS resin.
4. Associated attachments such as bottom cap, top cap, casing anchor, alignment tool, and grout cap shall be manufactured by RST Instrumentation and approved by the Engineer.
5. Inclinometers shall be measured during and after installation with an RST MEMS Digital Inclinometer System or other suitable device approved by the Engineer.
6. Inclinometer signal cable shall have a minimum length of 200 feet.

E. Dam Crest Survey Monuments

1. Survey monuments shall be imbedded into the embankment at least 18 inches and constructed 12-inch diameter corrugated CPE pipe backfilled with grout.
2. Grout shall have a minimum 2,000 psi compressive strength at 28 days.
3. The survey marker shall be 2½-inch diameter cast-in-place brass survey cap (Model M/M-BCS-2 1/2FS) as manufactured by Surv-Kap, or an equivalent approved by the Owner.

F. Underdrain Flow Meters

1. Underdrain Flow Meters shall be installed above the Underdrain Parshall Monitoring Flumes as shown on the Drawings.
2. Underdrain Flow Meters shall be of Open Channel Flow Meter type (Model Dynasonics iSonic 4000) as manufactured by Badger Meter, Inc., of Milwaukee, Wisconsin.
3. Ultrasonic transducer shall be the EchoPod DL-10 manufactured by Badger Meter.
4. Underdrain Flow Meters shall be capable of measuring flume water levels in standard Parshall Flumes with an accuracy 0.125 inches (3 mm).

3.0 EXECUTION

3.1 Vibrating Wire Piezometer Installation

- A. Impoundment (PZ-TI and PZ-WI Series) and Underliner VW Piezometers (PZ-TU and PZ-WU Series)
1. Installation of the Impoundment and Underdrain VW piezometers shall be installed at the locations identified on the Drawings and Geotechnical Monitoring Plan.
 2. Installation methods, materials, and data collection procedures shall be in accordance with manufacturer's recommendations and at the direction of the Engineer.
 3. VW Piezometers shall be placed in canvas sand filter bags provided by the piezometer manufacturer. Bags will be filled with No. 30 concrete sand with the piezometer centered in the bag.
- B. Embankment Foundation VW Piezometers (PZ-TF Series)
1. Installation of the Impoundment and Underdrain VW piezometers shall be installed at the locations identified on the Drawings and Geotechnical Monitoring Plan.
 2. Installation methods, materials, and data collection procedures shall be in accordance with manufacturer's recommendations and at the direction of the Engineer.

3. Boreholes shall be advanced below the TSF embankment foundation to the depths required for down-hole installation of the nested multi-point VW piezometers.
 - a. Boreholes shall be advanced to a minimum of 1 foot (12 inches) below the deepest VW piezometer.
 4. Downhole VW piezometers shall be installed using the Fully Grouted Method per RST Instruments recommendations.
 - a. A bentonite-Type I/II cement mix shall be used to backfill the boreholes after nested VW piezometer installation.
 - b. Viscosity of bentonite-cement backfill mix may be adjusted by the cutting short or additional bentonite to allow mixture to remain flowable for downhole pumping.
 - c. Care shall be taken to prevent air entrapment in the VW piezometer filter stone. The VW piezometers shall be installed upside down and secured to either the signal cable or PVC guide pipe.
 - d. If a PVC guide pipe is used during installation, it shall remain in place and be backfilled with bentonite-cement backfill mix.
 - e. The PVC guide pipe shall be terminated no shallower than 2 feet below the native ground surface.
- C. Calibrate piezometers to site-specific factors.
- D. All cable shall be placed to loosely meander in the trench and the riser casing to allow for settlement and avoid development of tension in cable. Minimum cable meander shall be between 12 inches and 18 inches of amplitude for every 36 inches of pitch.
- E. All cables shall be surrounded with Cable Bedding Fill as shown in the Drawings. Cable Bedding Fill will be compacted using hand-guided compaction equipment to form a smooth and non-yielding surface. Where placed as backfill in cable risers, Cable Bedding Fill shall be placed in lifts of 4 inches and tamped to a dense condition using a wood pole or rod.
- F. Survey the precise location and elevation of each of the piezometers to an accuracy of 0.1 feet in all directions. Survey the location of wiring and conduits leading to the piezometers to an accuracy of 0.5 feet. Provide the surveyed locations with the as-built documentation. Permanently label piezometers in the readout stations and protect the stations from damage due to traffic and construction operations.

3.2 Readout Station Installation

- A. Instrumentation Readout Stations shall be installed at the general locations shown on the Drawings.
- B. Installation Criteria and Validation: Field-mounted components and assemblies shall be installed and connected according to the requirements below:
1. Installation personnel have been instructed on manufacturers' installation requirements.
 2. Technical assistance from the Engineer is available to installation personnel at least by telephone.
 3. Installation personnel have one copy of the approved Drawings, Geotechnical Monitoring Plan and pertinent data.
 4. Power and signal wires shall be terminated with crimp type lugs, where the terminal block requires this.
 5. Connectors shall be, as a minimum, water tight.
 6. Wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.
 7. Wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected without splices unless specifically approved by the Engineer. Wiring shall be protected from sharp edges and corners.

- 8. Lightning protection shall be installed on the Readout Stations.
- C. Verify the correctness of each installation, including polarity of electric power and signal connections, and make sure process connections are free of leaks.

3.3 Inclinometer Installation

- A. Boreholes shall be advanced from the TSF embankment dam crest and into the clay foundation at the locations shown on the Drawings.
- B. Boreholes shall be advanced to a minimum of 1 foot (12 inches) below the deepest VW piezometer.
- C. Inclinometers shall be installed using the per RST Instruments recommendations.
- D. The "A" axis of the inclinometer shall be installed perpendicular to the dam alignment. Proper alignment of the casing shall be maintained at all times during installation. Casing shall not be twisted or pushed from top during installation.
- E. A bentonite-Type I/II cement mix shall be used to backfill the boreholes after nested VW piezometer installation.
- A. Viscosity of bentonite-cement backfill mix may be adjusted by the cutting short or additional bentonite to allow mixture to remain flowable for downhole pumping.

3.4 Dam Crest Survey Monument Installation

- A. Embankment Crest Survey Monuments shall be made an 18" diameter CPE pipe with smooth interior and backfilled with Lean Mix Concrete in accordance with Section 03300.
- B. A minimum 6-inch wide base of concrete shall be pours around the outside of the vertical CPE pipe to for a minimum depth of 6 inches from the base of the pipe.
- C. A 12-inch long $\frac{5}{8}$ inch diameter "All Thread" rod with coarse thread shall be cast plumb into the concrete with a minimum $2\frac{1}{2}$ inch extending above the top of the concrete.
- D. 1-inch diameter weep holes shall be drilled through the CPE pipe immediately above the top of the concrete to provide drainage of surface water. A minimum of six weep holes shall be installed equally spaced around the circumference of the CPE pipe.
- E. The annular space between the edges of the excavation and the CPE pipe shall be backfilled with Pipe Bedding Fill and placed in accordance with Section 02223.
- F. The CPE pipe shall be capped with a removable lid to protect concrete and survey monument.

3.5 Underdrain Flow Meter Installation

- G. Ultrasonic transducers shall be installed in accordance with the manufacturer's recommendation.
- H. Ultrasonic transducers shall be mounted to the Parshall Flumes using manufacturer-supplied mounting brackets.
- I. Signal cables shall be routed to Readout Station RS-3 shown on the Drawings.
- J. Signal cables shall be secured and protected from damage.
- K. Transducer readouts shall be installed in a weatherproof NEMA enclosure adjacent to the reclaim pond as shown on the Drawings.
- L. Weatherproof enclosure shall be mounted to fence post installed below grade and founded in Lean Mix Concrete meeting the requirements of Section 03300.
- M. Power shall be supplied to the transducers in either AC (275V max, 50-60 Hz) or DC (9 to 36 V, max 9W).

3.6 Calibration

- A. General: Devices provided shall be calibrated according to the manufacturer's recommended procedures to verify operation readiness and ability to meet the indicated functional and tolerance requirements.
- B. Calibration Points: When possible each instrument shall be calibrated at 5, 50, and 90 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.
- C. Bench Calibration: Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment.
- D. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument data sheets.

3.7 Performance Test

- A. All instruments shall operate for 30 days without failure.
- B. The Contractor shall furnish support staff as required to satisfy the repair or replacement requirements at no cost to the Owner.
- C. If any component fails during the performance test, it shall be repaired or replaced at no Cost to the Owner.

3.8 Acceptance

- A. The following conditions shall be fulfilled before the WORK is considered substantially complete:
 - 1. Submittals have been completed and approved.
 - 2. The instruments have been calibrated.
 - 3. Any necessary training has been performed.
 - 4. Spare parts and expendable supplies and test equipment have been delivered.
 - 5. The performance test has been successfully completed.
 - 6. Record drawings have been submitted.
 - 7. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.
 - 8. Debris associated with installation of instrumentation has been removed.

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