

DIVISION 2
TECHNICAL SPECIFICATIONS
REVISION 2

Final Closure

at

Riverbend Landfill
13469 Highway 18
McMinnville, Oregon 97128

Riverbend Landfill Company

April 2019

TABLE OF CONTENTS

BIDDING REQUIREMENTS

SECTION 02110	CLEARING, GRUBBING AND STRIPPING
SECTION 02219	STOCKPILING AND SOIL MANAGEMENT
SECTION 02221	EXCAVATING AND TRENCHING
SECTION 02223	REFUSE REMOVAL
SECTION 02225	SUBGRADE PREPARATION
SECTION 02227	GRANULAR DRAINAGE MATERIAL
SECTION 02249	EARTHFILL
SECTION 02710	POLYETHYLENE PIPE
SECTION 02771	GEOTEXTILE
SECTION 02779	LLDPE GEOMEMBRANE
SECTION 02800	INTERFACE TESTING PROGRAM

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EXPIRES: 31 December 2021

David J. Bonnett

**SECTION 02110
CLEARING, GRUBBING AND STRIPPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Stripping the grass, roots, plants, trees and debris from the limits of earthwork for construction as directed by the OWNER or as shown on the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02219 – Stockpiling and Soil Management
- B. Section 02221 – Excavating and Trenching
- C. Section 02225 – Subgrade Preparation

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

[Not Used]

PART 2 PRODUCTS

[Not Used]

PART 3 EXECUTION

3.01 PREPARATION

- A. Verify that any existing plant life designated to remain, is tagged or identified.
- B. Verify plants to be salvaged are tagged or identified.

3.02 PROTECTION

- A. Protect plant growth and any features designated to remain.
- B. Protect survey benchmarks from damage or displacement.
- C. Protect existing landfill gas and leachate management infrastructure located within the project area.

3.03 STRIPPING

- A. Strip grass, roots, and organic soils prior to excavating subsurface materials.
- B. Strip to a maximum depth of 6 inches below existing ground surface or as necessary to remove organic materials.
- C. CONTRACTOR to dispose of or stockpile stripped materials in OWNER-designated areas.
- D. CONTRACTOR shall remove vegetation in existing downchute that are being extended at the location of extension only.

3.04 FIELD CONSTRUCTION QUALITY ASSURANCE (CQA)

- A. The OWNER will perform construction quality assurance (CQA) testing during clearing, grabbing and stripping activities in accordance with the CQA Plan.
- B. Cooperate fully with the Owner in obtaining samples and performing tests and inspections. Include all costs for assistance in unit prices for work.

END OF SECTION

**SECTION 02219
STOCKPILING AND SOIL MANAGEMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Work under this section includes loading, hauling, placing, and constructing temporary or permanent stockpiles as needed for completion of the Work including temporary erosion and sediment controls.
- B. Soil management required to process in-place soils or stockpiled soils so they can be utilized for various earthworks.
- C. Management of soils is the CONTRACTOR'S responsibility; there will not be an extension of the contract time or additional compensation due to the moisture content of the in-place, imported or stockpiled soils.

1.02 RELATED SECTIONS

- A. Section 02110 – Clearing, Grubbing, and Stripping
- B. Section 02221 – Excavating and Trenching
- C. Section 02249 – Earthfill
- D. Section 02227 – Granular Drainage Material

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

- A. CONTRACTOR shall submit a Stockpile Work Plan a minimum of 20 work days prior receipt of any soils or use of stockpile areas. The Plan should include locations for stockpiling each material type, specific erosion and sediment control measures that will be implemented, and general management of these area. Modifications to this Plan may be submitted for review and approval throughout the project as needed.

PART 2 PRODUCTS

2.01 FOUNDATION SOIL

- A. Soils obtained from on-site or off-site sources that meet the requirements of Section 02249.

2.02 STRIPPED MATERIALS

- A. Grass, roots, plants, and organic soils resulting from work under Section 02110.

2.03 DEBRIS

- A. Material consisting of organic soils, trees, stumps, poles, brush mat, reinforced concrete,

and paving rubble.

2.04 VEGETATIVE SOIL

- A. Soils that meet the requirements of Section 02249 for Vegetative Layer in the final cover system.

2.05 GRANULAR DRAINAGE MATERIAL

- A. Granular soils obtained from off-site borrow areas that meet the requirements of Section 02227 for Granular Drainage Material.

PART 3 EXECUTION

3.01 STOCKPILING MATERIALS

- A. Debris and stripped materials shall be disposed at the locations selected by the Owner.
- B. Stockpiles shall not be located within the Landfill footprint, on top of the MSE berm, or along the toe of the MSE berm unless otherwise approved by the OWNER.**
- C. Locations of stockpiles shall be established in consultation with the OWNER and approved by the OWNER.
- D. CONTRACTOR shall load and haul surplus materials to stockpile location(s). Stockpiles shall be setback a minimum of 50 ft (15 m) from the property lines. Stockpiles of surplus soil shall be 6 to 10 ft (2 to 3 m) high, bladed smooth, and graded to drain. The stockpiles shall have 3H:1V (horizontal to vertical) side-slopes or flatter. The tops of the stockpiles shall have a minimum slope of 3%.
- E. Provide control to assure that materials go to appropriate stockpiles.
- F. Provide separation between stockpiles to allow equipment access.
- G. All surfaces shall be graded to drain.
- H. Place in loose layers not greater than 12 in. (300 mm) and compact by track walking with dozers.
- I. Shape each stockpile to uniform lines and grades.
- J. Water or cover stockpiles as necessary to control dust, prevent erosion, and control sediment.
- K. Slope stability, erosion control and drainage of slopes are the CONTRACTOR's responsibility.

3.02 FIELD CONSTRUCTION QUALITY ASSURANCE (CQA)

- A. The Owner will perform construction quality assurance (CQA) testing during clearing, grabbing and stripping activities in accordance with the CQA Plan.
- B. Cooperate fully with the Owner in obtaining samples and performing tests and inspections. Include all costs for assistance in unit prices for work.

3.03 SOIL MANAGEMENT

- A. Process excavated materials as necessary in stockpiles or in-place, if possible.

- B. As part of the project, plan for soil processing in stockpile areas to process excavated soils.
- C. Processing to meet the project requirements in these specifications may be required for, but not necessarily limited to the following: (i) clod size reduction; and (ii) conditioning soil to decrease or increase moisture content.
- D. Monitor organic stockpiles to detect and control fires.

3.04 CONSTRUCTION QUALITY CONTROL (CQC)

- A. CONTRACTOR may perform sampling and testing of materials, as deemed appropriate, to evaluate material types at the stockpile, at the material source, or at the place of use.
- B. OWNER will obtain samples and perform conformance testing as part of the Construction Quality Assurance (CQA) program.

END OF SECTION

**SECTION 02221
EXCAVATING AND TRENCHING**

PART 1 GENERAL

1.01 WORK INCLUDED

- A. All excavation and grading required to achieve the design slopes, widths, grades, and elevations shown on the Construction Drawings.
- B. On-site excavated materials will need to be processed and stockpiled for other uses such as Final Cover Foundation and Vegetative Soil.
- C. Dewatering of excavations as needed to complete the work.
- D. Shoring of excavations as needed to complete the work.
- E. Field construction quality control (CQC) and surveying.

1.02 RELATED SECTIONS

- A. Section 02110 – Clearing, Grubbing, and Stripping
- B. Section 02223 – Refuse Removal
- C. Section 02225 – Subgrade Preparation
- D. Section 02249 – Earthfill
- E. Section 02710 – Polyethylene Pipe

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

- A. Submit to OWNER, at least 7 calendar days before commencing any excavation, documentation that utility clearance was performed in accordance with Part 3.01 of this Section.
- B. CONTRACTOR shall prepare and submit to OWNER, within 10 business days of contract authorization, a Dewatering Plan for the various phases of the work for approval by the OWNER. This Dewatering Plan may require update as needed to address site conditions after the start of work. The CONTRACTOR must comply with local, state, and federal guidelines for water management where applicable.

PART 2 PRODUCTS

[Not Used]

PART 3 EXECUTION

3.01 PREPARATION

- A. CONTRACTOR is responsible for all aspects of worker safety during excavation/grading

activities.

- B. Institute health and safety monitoring if excavating through waste.
- C. Identify required lines, levels, contours, and datum by survey.
- D. Locate, identify, and protect utilities from damage. Notify Utility Notification Center to locate utilities, if applicable.
- E. Implement erosion and sediment control plan before beginning excavations.
- F. Prior to any excavation notify OWNER and evaluate utility locations.
- G. Provide for dust control.
- H. Protect bench marks and erosion control facilities from excavation equipment and vehicular traffic.
- I. Protect all existing infrastructure located within the work area.
- J. Notify OWNER of unexpected subsurface conditions and discontinue affected work until notified by OWNER to resume work.

3.02 SUBGRADE EXCAVATION/GRADING

- A. Establish by survey the excavation control shown on the grading plan.
- B. Grade top perimeter of excavation to prevent surface water from draining into excavation.
- C. Excavate to the lines, grades, and elevations shown on the Construction Drawings.
- D. Haul and stockpile excavated materials to the locations selected by the OWNER. CONTRACTOR can reuse excavated soils provided the material meets the requirements listed in the respective technical specifications.
- E. Remove and segregate lumped subsoil, boulders, and rocks greater than 3 inches in largest dimension from completed subgrade surface.
- F. Over-excavated or eroded areas below the subgrade elevation shall be backfilled in accordance with the requirements of Section 02249.

3.03 TRENCH EXCAVATION

- A. Trench excavation shall follow the alignment shown on the Construction Drawings
- B. Excavation to a greater depth shown on the Construction Drawings may be required if the native material at the bottom of the trench will not provide proper support for the structure. The need for over excavation shall be demonstrated through relevant field testing.
- C. The CONTRACTOR shall use appropriate means, methods and/or techniques to control the widths of trenches and roughness of trench walls
- D. If the trench width exceeds the limits shown on the Construction Drawings, the CONTRACTOR shall be responsible for all extra work and changed conditions resulting from widening the excavation.
- E. The CONTRACTOR is responsible for all extra work or changed conditions resulting from inadequate dewatering techniques which cause the trench bottom to fail to provide proper support for the structure.
- F. Excavations shall be large enough to make joints and permit inspection by the OWNER.

3.04 DEWATERING

- A. CONTRACTOR shall be prepared to dewater during the duration of the project and shall follow the approved Dewatering Plan as needed.
- B. CONTRACTOR dewatering shall consider construction sequencing and seasons.
- C. CONTRACTOR dewatering shall not affect existing structures and improvements.
- D. CONTRACTOR shall dispose of groundwater resulting from excavations as required by State and Federal regulations and as approved by the OWNER.
- E. Dewatering is considered incidental to the project Work and its cost shall be included in appropriate Bid Items.

3.05 FIELD CONSTRUCTION QUALITY CONTROL (CQC)

- A. Provide for visual inspection of surfaces.
- B. No earthwork or bedding/backfill shall be placed on any excavated subgrade or trench bottom until the excavated subgrade is approved by the OWNER.
- C. Perform as-built surveys as required to document excavation limits.
- D. Unless otherwise noted, tolerances are:
 - 1. Horizontal ≤ 0.5 foot
 - 2. Vertical ≤ 0.1 foot
- E. Field Measurements
 - 1. Verify that survey bench marks are consistent with the design.
 - 2. Verify quantities of excavation as required by the Measurement & Payment requirements of the Contract Documents.

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

**SECTION 02223
REFUSE REMOVAL**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Refuse removal and relocation that is required during excavating, grading, trenching, or other construction activities.

1.02 RELATED SECTIONS

- A. Section 02221 – Excavating and Trenching
- B. Section 02225 – Subgrade Preparation

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan

1.03 SUBMITTALS

- A. A waste excavation and disposal plan shall be submitted to the OWNER for approval prior to start of waste removal.

PART 2 MATERIALS

[Not Used]

PART 3 EXECUTION

3.01 REFUSE REMOVAL AND RELOCATION

- A. Refuse will be encountered during construction.
- B. When encountered, excavate refuse and dispose in coordination with the OWNER. Coordinate refuse excavation and disposal with OWNER.
- C. Some of excavated waste may be used to re-grade subgrade areas being prepared for closure (i.e., placement of the final cover system).
- D. Contractor shall control surface water in areas of open excavation so that leachate generation and leachate runoff is avoided.
- E. Contractor shall be ready to control and pump liquids as needed.
- F. Contractor shall dispose of liquids at locations approved by the OWNER.
- G. Areas of excavated waste that have reached design elevations shall be covered at the end of each working day with appropriate soil as shown on the Construction Drawings (e.g., Foundation Soil).
- H. Areas of excavated waste that have not reached design elevations shall be covered at the end of each working day with soil or methods approved by the OWNER such as tarps, etc.

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

**SECTION 02225
SUBGRADE PREPARATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Final grading of soils in preparation for placement of geosynthetics.

1.02 RELATED SECTIONS

- A. Section 02221 – Excavating and Trenching
- B. Section 02249 – Earthfill
- C. Section 02771 – Geotextile
- D. Section 02779 – LLDPE Geomembrane

1.03 REFERENCES

- A. ASTM D1557 - Standard Test Methods for Moisture/Density Relations of Soils and Soil-aggregate Mixtures Using 10-pound Rammer and 18-inch Drop
- B. ASTM D2216 – Standard Method for Laboratory Determination of Water (moisture) Content of Soil and Rock
- C. ASTM D2922, ASTM D3017 - Standard Test Methods for Density and Moisture Content of Soils and Soil-aggregate in Place by Nuclear Methods
- D. Construction Quality Assurance (CQA) Plan

PART 2 PRODUCTS

2.01 MATERIALS

- A. Earthfill: Section 02249
- B. Excavating and Trenching: Section 02221

PART 3 EXECUTION

3.01 FINAL GRADING

- A. Prepared subgrade (i.e., foundation soil layer) shall be compacted as specified in Section 02249. Excavated areas not satisfying this requirement shall be over-excavated 6 inches or more, as determined by the OWNER, and backfilled with compacted soil material.
- B. Remove any angular or sharp rocks and all debris from the completed subgrade surface.
- C. Remove all observable rocks or clods greater than 3/8-inch protruding from the completed subgrade surface.
- D. Steel drum roll or use a smooth plate to smoothen all surfaces prior to placement of geosynthetics.
- E. Grade subgrade to a vertical tolerance of plus or minus 0.10-foot.

- F. Completed subgrade surface must have no vertical irregularities greater than 0.25-inch or abrupt grade transitions. The surface should provide for a continuous, intimate contact with the overlying geosynthetics (excluding geogrid).
- G. All grade breaks must have a minimum radius of 1 foot.
- H. Round corners of sumps and slope transitions into base of module. Minimum radius: 1 foot, maximum radius: 2 feet (unless specified otherwise).
- I. Before placing any materials in areas of the subgrade where excessive moisture is encountered, place a separator geotextile, gravel, and another separator geotextile (Note: pipes to drain the water may also be necessary). CONTRACTOR may need to dewater the area during construction.
- J. CONTRACTOR is responsible for maintaining the prepared subgrade until the INSTALLER has accepted the subgrade for the overlying geosynthetics (excluding geogrid).
- K. After acceptance of subgrade, CONTRACTOR responsible for surface water control(s) so that runoff and/or run-on do not damage already-deployed geosynthetics. Coordination with INSTALLER is required.

3.02 FIELD CONSTRUCTION QUALITY ASSURANCE

- A. The OWNER will perform construction quality assurance (CQA) testing during geosynthetics subgrade preparation in accordance with the CQA Plan.

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

**SECTION 02227
GRANULAR DRAINAGE MATERIAL**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Placement of granular drainage material at the locations shown on the drawings.
- B. Work includes furnishing, loading, hauling, placing and compacting the material.

1.02 RELATED SECTIONS

- A. Section 02710 – Polyethylene Pipe
- B. Section 02771 – Geotextile

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan
- B. Latest (and applicable, depending on materials being tested) version of the ASTM International standards:
 - 1. ASTM D422 - Standard Method for Particle-Size Analysis of Soils
 - 2. ASTM D2434 - Standard Method for Permeability of Granular Soils (Constant Head)
 - 3. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

1.04 SUBMITTALS

- A. Submit a 50-pound representative sample of the proposed gravel within 10 calendar days after contract award.

PART 2 PRODUCTS

2.01 GRANULAR DRAINAGE MATERIAL

- A. Durable and hard gravel obtained and imported from off-site borrow source.
- B. Free of organic or other deleterious material.
- C. Having a hydraulic conductivity greater than or equal to 1 cm/sec (ASTM D2434) when placed in accordance with this specification.
- D. Containing no limestone or other material that may adversely react with landfill leachate.
- E. Particles shall be rounded to subrounded (ASTM D2488).
- F. Gradation:

<u>U.S. Sieve Size</u>	<u>Percent Passing</u>
3/8-inch	100
No. 4	0 – 40
No. 10	0 – 20
No. 40	0 – 5
No. 200	0 – 2

PART 3 EXECUTION

3.01 PLACEMENT

- A. Place materials only when underlying excavations, foundations, and geosynthetic installations are complete and accepted by OWNER in accordance with Specifications.
- B. Place to lines and grades shown on the Construction Drawings.
- C. Place to the uniform thickness shown on the Construction Drawings.
- D. Place without damaging underlying geosynthetics.
- E. Grade tolerance: $\leq +0.1$ foot.
- F. Do not cause underlying geosynthetics to bridge across ditch alignments or pipe alignments. If bridging does occur, repair by installing additional compensating geosynthetic materials at no additional cost to the OWNER.

3.02 PIPE INSTALLATION

- A. Comply with Section 02710 for assembly of pipe runs.
- B. Install to the lines and grades shown on the Construction Drawings.

3.03 FIELD CONSTRUCTION QUALITY CONTROL (CQC)

- A. Prior to beginning gravel placement, Contractor shall provide methodology for placing gravel so that the underlying geosynthetic materials are not damaged.

3.04 GRANULAR DRAINAGE MATERIAL IN CONTACT WITH GEOSYNTHETICS

- A. Equipment used for placing gravel shall not be driven directly over geosynthetics. A minimum thickness of 1 ft of soil material is required between a low ground pressure dozer (Caterpillar D-4H LGP bulldozer or equivalent) and underlying geosynthetics. A minimum thickness of 3 ft of material is required between rubber-tired vehicles and underlying geosynthetics. Equipment shall place material without braking. In areas of heavy vehicle traffic, such as access ramps, the material thickness should be at least 3 ft. The following table shall be complied during construction:

Maximum Equipment Ground Pressure (psi)	Initial Lift Thickness (ft)
5	1.0
10	1.5
20	2.0
>20	>3.0

3.05 FIELD CONSTRUCTION QUALITY ASSURANCE (CQA)

- A. The OWNER will perform CQA services (observation, inspection, testing) during gravel placement in accordance with the CQA Plan.
- B. Assist the OWNER as necessary in collecting material samples and conducting tests.

END OF SECTION

**SECTION 02249
EARTHFILL**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Placing and compacting soil for earthfill, which includes:
 - 1. anchor trench backfill;
 - 2. foundation soil (final cover); and
 - 3. vegetative soil (final cover).
- B. Work includes the excavation, moisture-conditioning (disking, drying, etc.), segregation, stockpiling, placing and handling of soils to allow the construction of the project. To access sources of borrow materials, CONTRACTOR shall obtain prior approval from the OWNER.

1.02 RELATED SECTIONS

- A. Section 02219 – Stockpiling and Soil Management
- B. Section 02221 – Excavating and Trenching
- C. Section 02223 – Refuse Removal
- D. Section 02225 – Subgrade Preparation
- E. Section 02710 – Polyethylene Pipe
- F. Section 02779 – LLDPE Geomembrane
- G. Section 02800 – Interface Testing Program

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan
- B. Latest (and applicable, depending on materials being tested) version of the ASTM International standards:
 - 1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils
 - 2. ASTM D1140 – Standard Test Methods for Determining the Amount of Material Finer than 75- μ m (No. 200) Sieve in Soils by Washing
 - 3. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
 - 4. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft³ (2,700kN-m/m³))
 - 5. ASTM D2216 - Standard Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
 - 6. ASTM D2434 – Standard Test Method for Permeability of Granular Soils (Constant Head)
 - 7. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
 - 8. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

9. ASTM D2937 – Standard Test Method for Density of Soils by the Drive Cylinder Method
10. ASTM D4221 - Standard Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer
11. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
12. ASTM D5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter
13. ASTM D-5321 Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
14. ASTM D-6243 Standard Test Method for Determining the Internal and Interface Shear Strength of Geosynthetic Clay Liner by the Direct Shear Method
15. ASTM D6938 Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.04 SUBMITTALS

- A. Dewatering and shoring shall be designed by a Registered Professional Engineer in the State of Oregon and submitted to the OWNER.

PART 2 PRODUCTS

2.01 ANCHOR TRENCH BACKFILL

- A. Anchor trench backfill shall consist of excavated on-site soils free from landfill waste, organic materials, and other materials, which may be highly compressible or which cannot be properly compacted.
- B. Shall not contain blocks, broken concrete, masonry rubble, debris, expansive soil, or other deleterious material.
- C. Maximum particle size of 3/8 in. in largest dimension.

2.02 FOUNDATION SOIL (FINAL COVER)

- A. Foundation layer material shall be composed of general fill consisting of soil free from organic materials, loam, wood, rubble, broken concrete, trash, and other objectionable materials, which may be compressible or which cannot be properly compacted or can damage the overlying geomembrane.
- B. Shall meet a laboratory hydraulic conductivity equal to or less than 1×10^{-5} cm/sec when tested in general accordance with ASTM D5084 at a confining pressure of 5 psi.
- C. Shall meet the interface strengths listed in Section 02800.
- D. In the top 6 inches of compacted foundation layer, the maximum particle size shall not exceed 3/8-inch in largest dimension. Below the top 6 inches of compacted foundation layer, the maximum particle size shall not exceed 3 inches.

2.03 VEGETATIVE SOIL (FINAL COVER)

- A. The vegetative soil is the organic soil placed above the final cover geosynthetics for the purpose of supporting vegetation.
- B. Soil shall be natural (i.e., not recycled or from waste materials), from on-site sources, and free of excess moisture.
- C. Soil shall be free of wood, rubble, broken concrete, trash, and other objectionable materials that can damage the underlying geosynthetics.
- D. The maximum particle size shall not exceed 2 inches in largest dimension..

PART 3 EXECUTION

3.01 PREPARATION

- A. Verify soils meet requirements for compacted soil before commencing work.
- B. Where excessive moisture is encountered, consider installing a dewatering system before placing any material above areas of the subgrade.
- C. CONTRACTOR shall be prepared to shore the excavations.
- D. Liquids from dewatering shall be disposed as required by the State of Oregon regulations and the CONTRACTOR's Dewatering Plan.
- E. If required by OWNER, prior to beginning soil placement, demonstrate that placement techniques will not damage the adjacent geosynthetic materials.

3.02 PLACEMENT – GENERAL REQUIREMENTS

- A. Scarify, moisture condition, and compact surfaces that will receive fill to a minimum of 90 percent of maximum dry density in accordance with ASTM D1557.
- B. Scarify and moisture condition the top of each compacted lift before placing subsequent lift.
- C. Bench or key compacted soil into existing subgrades and side slopes. Provide bench widths equal to or greater than the compaction equipment.
- D. Areas inaccessible to large compaction equipment shall be compacted with small mechanical or vibratory compactors.
- E. Do not place fill under water.
- F. Repair all eroded and desiccated soil areas before placing subsequent lifts.
- G. Compacted lift thickness shall not exceed 6 inches.
- H. Loose lift thickness shall not exceed 8 inches.
- I. Grade final compacted soil surfaces to remove ruts and gouges. Finish compacted soil above grade by track-walking perpendicular to slope contours so that track marks are parallel to the contours.

- J. Tolerances:
 - 1. Horizontal ≤ 0.5 foot
 - 2. Vertical ≤ 0.1 foot

3.03 PLACEMENT - ANCHOR TRENCHES (AND TERMINATIONS)

- A. Place geosynthetic materials in the anchor trenches as shown in the Construction Drawings.
- B. Compact backfill to a minimum of 90 percent of maximum dry density and at moisture contents between -3 and +3 of the optimum moisture content as determined by ASTM D1557.
- C. Do not place fill if anchor trench has water in it.
- D. Scarify the top of each compacted lift before placing subsequent lift.
- E. Place and compact fill to the lines, grades, cross sectional requirements, and dimensions shown on the Construction Drawings.
- F. Grade final fill surfaces to remove ruts and gouges.
- G. Finish fill above grade by wheel-rolling along the length of the anchor trench.

3.04 PLACEMENT

- A. CONTRACTOR shall sequence the work so that the various materials can be placed in tandem and alternate lifts.
- B. Backfill surface shall be graded to avoid ponding or overtopping by storm-water runoff. At the end of each day's work, the fill shall be worked such that positive drainage off the working platform is maintained.
- C. CONTRACTOR is made aware that piping and other appurtenances such as anchor trenches and liner components need to be placed as the final cover is constructed; therefore, staging and sequencing of the various materials will be necessary.
- D. Surfaces that will receive liner components need to meet the requirements for subgrade preparation in Section 02225.

3.05 PLACEMENT – FINAL COVER MATERIALS (FOUNDATION LAYER and VEGETATIVE LAYER SOILS)

- A. Foundation Layer Soil - shall be placed and compacted to 90 percent of the maximum dry density as determined by ASTM D1557. Relative compaction and placement moisture may need to be adjusted to meet the hydraulic conductivity requirement listed in Part 2.02B of this specification and the interface strength requirements listed in Section 02800. The placement moisture content may be near or higher than the optimum moisture content. Compaction of the Foundation Layer Soils shall be by equipment capable of producing a kneading action for the full depth of each lift. A padfoot, sheepsfoot, or tamping feet roller shall be used, unless approved otherwise by the Engineer. Foundation Layer having a hydraulic conductivity, moisture content, or dry density that does not meet the criteria specified shall be reworked and recompacted to obtain the specified hydraulic conductivity, moisture content, and dry density.

- B. Vegetative Layer Soil - shall be placed and compacted to 85 percent of the maximum dry density and at moisture contents between -5 and +3 of the optimum moisture content as determined by ASTM D1557.
- C. Construction equipment shall not be operated directly upon geosynthetics - see Part 3.06 of this Section for more details.
- D. A loose soil thickness of at least 12 inches shall be maintained over the geosynthetics in order to operate tracked vehicles. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the soil and damaging the underlying geosynthetics.
- E. Backfill surface shall be graded to avoid ponding or overtopping by stormwater run-off.
- F. Soils shall be placed over the geosynthetics in such a manner that minimizes the development of wrinkles in and/or movement of the geosynthetics. At the end of each day's work, the fill shall be worked such that positive drainage off the working platform is maintained.

3.06 EQUIPMENT FOR PLACING SOIL OVER GEOSYNTHETICS

- A. Equipment used for placing soils shall not be driven directly over geosynthetics. A minimum thickness of 1 ft of material is required between a low ground pressure dozer (such as a Caterpillar D-4H LGP bulldozer or equivalent) and underlying geosynthetics. A minimum thickness of 3 ft of material is required between rubber-tired vehicles and underlying geosynthetics. Equipment shall place material without braking. In areas of heavy vehicle traffic, such as access ramps, the material thickness should be at least 3 ft. In any case, the following table shall be complied with during construction:

Maximum Equipment Ground Pressure (psi)	Initial Lift Thickness (ft)
5	1.0
10	1.5
20	2.0
>20	>3.0

3.07 FIELD CONSTRUCTION QUALITY ASSURANCE (CQA)

- A. The OWNER will perform CQA testing during earthfill placement in accordance with the CQA Plan.
- B. CONTRACTOR shall cooperate fully with the OWNER in scheduling and performing field CQA tests and inspections. Include costs for coordination and assistance in unit prices.

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

**SECTION 02710
POLYETHYLENE PIPE**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Installing solid (non-perforated) and perforated High Density Polyethylene (HDPE) SDR 17 or 21 pipes, associated pipe fittings, caps, and connections as shown in the Construction Drawings for landfill and surface water applications.
- B. Material will be purchased by the OWNER based on quantities determined by the CONTRACTOR. Material supplier and CONTRACTOR shall coordinate with OWNER for delivery of material to the site for installation.
- C. Installation of geotextiles associated with pipes may be by the Installer with coordination with the OWNER.

1.02 RELATED SECTIONS

- A. Section 02221 – Excavating and Trenching
- B. Section 02227 – Granular Drainage Material
- C. Section 02771 – Geotextile

1.03 REFERENCES

- A. Latest (and applicable, depending on materials being tested) version of the ASTM International standards.
 - 1. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
 - 2. ASTM D696 - Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics between -30°C and 30°C with a Vitreous Silica Dilatometer
 - 3. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
 - 4. ASTM D790 - Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - 5. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
 - 6. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique
 - 7. ASTM D1525 - Standard Test Method for Vicat Softening Temperature of Plastics
 - 8. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics
 - 9. ASTM D2240 - Standard Test Method for Rubber Property– Durometer Hardness
 - 10. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
 - 11. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
 - 12. ASTM D3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
 - 13. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

14. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
 15. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
 16. ASTM F1473 - Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins
- B. National Sanitation Foundation (NSF)
NSF Standard Number 14 - Plastics Piping Components and Related Materials
 - C. PPI - Plastic Pipe Institute
 - D. ANSI - American National Standards Institute
 - E. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

- A. Submit with each shipment of pipe to site, Manufacturer's certification of compliance with specified requirements of this Section. Submit catalog cut sheet of pipe and fittings to be supplied prior to commencing work.
- B. Provide written certification for qualified HDPE pipe fusion welders.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

- A. High density polyethylene (HDPE). Polyethylene resin shall meet or exceed the requirements of ASTM D3350 for PE 4710 material with a Cell Classification of 445464C, or better.
- B. All pipe sizes shown on the Construction Drawings and specified in this Section reference nominal diameter, unless otherwise indicated on the Construction Drawings or in this Section. Pipe sizing and workmanship are to be in accordance with ASTM F714 and ASTM D3035.
- C. Containing no recycled compound except that generated in the Manufacturer's own plant and from resin of the same specification from the same raw material supplier.
- D. Resin for pipe and fittings to be listed by both N.S.F. and P.P.I. and manufactured in accordance with ASTM D3350 and ASTM F714.
- E. Homogeneous throughout and free of visible cracks, holes (except where specified or shown), foreign inclusions or other injurious defects. Being uniform in color, capacity, density, and other physical properties.

Property	ASTM Test Designation	Unit	Minimum Requirements
Density	D1505	gm/cm ³	0.947
Melt Index	D1238	gm/10 min	<0.15
Flexural Modulus	D790	psi	110,000
Tensile Strength	D638	psi	3,000
PENT (Notch Tensile)	F1473	Hrs.	>100
Hydrostatic Design Basis	D2837	psi	1,600
UV Stabilizer	D1603	% Carbon Black	2%
Elastic Modulus	D638	psi	130,000
Brittleness Temperature	D746	°F	<-180°F
Vicat Softening Temperature	D1525	°F	+255°F
Thermal Expansion Coefficient	D696	in/in/°F	1.2x10 ⁻⁴
Hardness	D2240	Shore "D"	65

- G. Provide pipe with the following information continuously marked on the pipe or spaced at intervals not exceeding 5 feet.
1. Name and/or trademark of the pipe manufacturer.
 2. Nominal pipe size.
 3. Standard Dimensional Ratio (SDR).
 4. PE Designation.
 5. Manufacturer's Standard Reference.
 6. A production code, from which the date and place of manufacture can be determined.

2.02 FITTINGS

- A. Provide fittings, manufactured from the same class of materials and fully compatible with the HDPE pipe.
- B. Provide fittings manufactured in accordance with ASTM D3350 and ASTM D3261. Provide fabricated fittings with pressure ratings matching or exceeding the HDPE pipe.

2.03 PERFORATED PIPE

- A. Perforations: As shown on the Construction Drawings.
- B. OWNER will visually inspect all pipe prior to installation or fusion welding.
- C. Perforations shall be clean of drilling shavings.

PART 3 EXECUTION

3.01 PIPE INSTALLATION GENERAL REQUIREMENTS

- A. When shipping, delivering, and installing pipe, fittings, and accessories, do so in such manner to ensure a sound, undamaged installation.
- B. Provide adequate storage for all materials and equipment delivered to the job site.
- C. Handle and store pipe and fittings in accordance with the manufacturer's recommendations.

3.02 PLACING AND LAYING PIPE

- A. Provide required maintenance of all such materials and equipment used to handle, place, and lay pipe.
- B. Follow the manufacturer's recommendations when hauling, unloading and stringing the pipe.
- C. Take precautions to prevent damage to the pipe.
- D. Do not push, pull, or drag pipe and fittings over sharp projections, or drop or have objects dropped on the pipe and fittings.
- E. Inspect for defects before and during installation. Remove any piping showing kinks, buckles, cuts, gouges, or any other damage, which in the opinion of the OWNER will affect performance of the pipe.
- F. Replace material found to be defective before or after laying with sound material without additional expense to the OWNER.
- G. Carefully lower pipe and accessories into the trench.
- H. Under no circumstances drop or dump materials into the trench.
- I. Rest the full length of each section of pipe solidly upon the pipe bedding.
- J. Take up or relay pipe that has had the grade disturbed while joining or laying the pipe.

3.03 FUSION WELDING PIPE

- A. Join the HDPE pipe by the method of thermal butt or side wall fusion, as outlined in ASTM D2657 or as recommended by the pipe manufacturer. Perform fusion joining of pipe and fittings in accordance with the procedures established by the pipe manufacturer. Of particular importance is the use of proper interface pressures and heater plate temperatures.
- B. Use fusion pressures, temperatures, and cycle times according to pipe manufacturer's recommendations. Only use personnel adequately trained and qualified in the technique involved
- C. Do not perform pipe fusion in water or when trench conditions are unsuitable for the work. Keep water out of the trench until joining is completed. Secure open ends of pipe and close valves when work is not in progress, so that no trench water, earth, animals, or other substance will enter the pipe or fittings. Plug, cap or valve off pipe ends left for future connections as shown on the Construction Drawings.
- D. Clear and grade fusion welding sites, if necessary, to provide enough space for pipe storage and fusion equipment. Keep the site free of rocks, stumps and debris which could cut, scar, or gouge the pipe. In order to allow the joining operation to continue in adverse weather conditions, a shelter may be required for the joining machine. Particular caution should be exercised to prevent water from entering the inside of the pipe and from coming in contact with the heater plate.

- E. Properly clamp pipe to be fused, clean and prepare faces being fused. Apply heat source to properly melt followed by pressure to create roll back bead and allow to properly cool in accordance with the pipe manufacturer's recommendations. Pressure testing of fabricated pipe section is required for pressurized system.
- F. Polyethylene Fusion Welder's Qualification: All pipe fusion welding must be performed by a Manufacturer-certified fusion welding operator.
- G. Provide for instruction, testing, and installation training sessions as required to obtain training for welding personnel, including quality control personnel, in polyethylene fusion machine operation, instruction and familiarization with HDPE pipe and fitting fusion for the project. Only fully trained personnel will be allowed to perform the installation, supervision, or inspection of polyethylene-fusion joints. Submit to the OWNER, at least 5 business days prior to beginning fusion welding, a list of those personnel authorized, instructed and certified for polyethylene fusion. Make all on-site training sessions conducted during this Contract available to quality assurance personnel at no charge to the OWNER.
- H. Training: Provide assistance from the manufacturer/supplier in instructing welding personnel in proper fusion welding procedures and techniques. Notifications will be required in writing, listing the names of those persons so familiarized. A manufacturer's representative shall be certified in writing by the Manufacturer to be technically qualified and experienced in fusion welding of HDPE pipe.

3.04 INSTALLING FLANGED CONNECTIONS

- A. Bolt flanges using an evenly torqued crossing pattern. Retorque after 1 hour in the same crossing pattern.
- B. Polyethylene flanges must be at the ambient temperature of the surrounding soil at the time they are bolted tight to prevent relaxation of the flange bolts and loosening of the joint due to thermal contraction of the polyethylene materials. Wait at least 24-hours after initial flange bolt tightening, then re-tighten flange bolts again.

3.05 FIELD CONSTRUCTION QUALITY ASSURANCE (CQA)

- A. The OWNER will perform CQA testing during polyethylene pipe installation in accordance with the CQA Plan.
- B. Cooperate fully with the OWNER in obtaining samples and performing tests and inspection/observation. Include all costs for assistance in unit prices for work.

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

**SECTION 02771
GEOTEXTILE**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Furnishing and installing geotextile as shown on the Construction Drawings and in accordance with this Section.
- B. Material supplier and CONTRACTOR shall coordinate with OWNER for performing conformance testing and interface strength testing before delivery of material to the site for installation. Conformance and interface test results shall be approved by OWNER before geotextile shipment to the site.
- C. **The geotextiles for this project shall not be heat-burnished.**

1.02 RELATED SECTIONS

- A. Section 02227 – Granular Drainage Material
- B. Section 02710 – Polyethylene Pipe
- C. Section 02779 – LLDPE Geomembrane
- D. Section 02800 – Interface Testing

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan
- B. Latest (and applicable, depending on materials being tested) version of the ASTM International standards:
 - 1. ASTM D4355 - Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water
 - 2. ASTM D4491 - Standard Test Method for Water Permeability of Geotextiles by Permittivity
 - 3. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles
 - 4. ASTM D4632 - Standard Test Method for Breaking Load and Elongation of Geotextiles (grab method)
 - 5. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile
 - 6. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
 - 7. ASTM D5261 - Standard Test Method for Determining the Mass per Unit Area of Geotextiles
 - 8. ASTM D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.04 DEFINITIONS

- A. **MANUFACTURER:** Responsible for the production of geotextile rolls.
- B. **INSTALLER:** The party responsible for field handling, storing, deploying, repairing, anchoring, and any other aspects of installing the geotextile.

- C. Construction Quality Assurance (CQA) Consultant/Organization: The party, independent from the MANUFACTURER or INSTALLER, responsible for observing and documenting activities related to the quality assurance of the production and installation of the geosynthetic components of the geotextile. Also responsible for issuing a construction monitoring report, and certification sealed by a Registered Professional ENGINEER.

1.05 SUBMITTALS

- A. Submit, at least 10 calendar days prior to confirmation of OWNER-CONTRACTOR Agreement, samples and complete description of geotextile fabric proposed for use that meet or exceed requirements of this section including that the materials that will be supplied are not heat burnished. Include certified minimum or minimum average roll value (MARV) property values and test methods used to obtain property values. Also include production capacity available and projected delivery dates.
- B. Submit, at least 10 calendar days prior to installation, written instructions for storage, handling installation, and seaming of proposed geotextile.
- C. Submit, at least 10 calendar days prior to installation, documentation attesting to in-ground durability of geotextiles.
- D. Submit, at least 10 calendar days prior to installation, written instructions for repair of geotextile.
- E. Submit, at least 10 calendar days prior to delivery, MANUFACTURER's certificates of compliance with specified product requirements. This submittal includes MANUFACTURER's Quality Control (MQC) testing certificates signed by responsible party. Include lot, batch, and roll numbers, sampling procedures, test procedures, and test results.
- F. Warranty: Submit to OWNER prior to installation, MANUFACTURER's, and INSTALLER's written warranty against product and installation defects. Limits of liability must be accepted by the OWNER.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect geotextile from ultraviolet light exposure, precipitation, inundation, mud, dirt, dust, puncture, cutting, and other damaging or deleterious condition.
- B. Immediately restore damaged protective covering.

PART 2 PRODUCTS

2.01 GENERAL

- A. Products comprised of non-woven, needle-punched polypropylene or polyester fabric; oriented into a staple network that maintains its structure during handling, placement, and long-term service.
- B. The product shall not be heat burnished.
- C. New product made from virgin materials.

2.02 NONWOVEN GEOTEXTILE PROPERTIES

- A. Geotextile shall conform to the following minimum average roll values (MARV), as defined by the Federal Highway Administration (FHWA), for the properties listed in the tables below.

Requirements for 8 ounce/syd geotextile

Test	ASTM Test Designation	Unit	Minimum Requirement
Polymer Composition (polyester or polypropylene)	N/A	%	> 95
Mass per unit area	D5261	oz/yd ²	> 8
Grab Tensile	D4632	lbs	> 225 (1)
Puncture Resistance	D6241	lbs	>575
Trapezoidal Tear	D4533	lbs	>90
Permittivity	D4491	1/sec	>1.0
UV Resistance	D4355	% strength	>70
Apparent Opening Size	D4751	mm	<0.21
1. Average of machine and transverse direction values.			

- B. Geotextile shall be chemically inert when immersed in the leachate from a typical sanitary landfill.

2.03 MANUFACTURER QUALITY CONTROL (MQC)

- A. The Geotextile MANUFACTURER shall sample and test the geotextiles at a minimum of once for every 100,000 square foot per lot/batch. Test results shall demonstrate that the material conforms to all requirements in Part 2.02 of this Section, except for UV Resistance, which shall be certified by the MANUFACTURER.
- B. OWNER will reject rolls for which quality control requirements are not met.
- C. Certify the quality of the rolls of geotextile.
- D. Provide MQC certificates for each roll delivered to the site. The MQC certificates must include:
1. Roll numbers and identification.
 2. Sampling procedures.
 3. Results of quality control tests, including a description of test methods used.

2.04 LABELING

- A. Mark or tag geotextile rolls with the following information:
1. MANUFACTURER's name.
 2. Product identification.
 3. Lot number or date.

4. Roll number.
 5. Roll dimensions.
- B. Mark special handling requirements on rolls.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Prior to installation of geotextile, examine underlying construction for conformance with specifications.

3.02 PROTECTION

- A. When placing soil materials over geotextile ensure the following:
1. No damage to geotextile.
 2. No slippage of geotextile on underlying layers.
 3. No excessive tensile stresses in the geotextile.
- B. Ensure that geotextiles are covered within 15 calendar days of deployment.
- C. On side slopes, sacrificial geomembrane shall be placed above the geotextile. Sacrificial geomembrane shall be removed by OWNER before placing operations layer on the side slope.

3.03 DEPLOYMENT

- A. Follow MANUFACTURER's recommendations, standards, and guidelines.
- B. Roll geotextile down slope keeping the geotextile sheet in sufficient tension to prevent folds and wrinkles.
- C. Weight geotextile with sandbags, or equivalent, to ballast during deployment. Leave ballast in place until geotextile is covered with succeeding construction layer.
- D. Cut geotextile using approved cutter only. Take care to protect other in-place geosynthetic materials when cutting geotextile.
- E. Do not trap dust, stones, or moisture in geotextile that could damage or clog drains or filters, or hamper subsequent seaming.
- F. Examine geotextile over entire completed surface to ensure that no potentially harmful foreign objects, such as needles, are present. Remove any foreign objects.

3.04 SEAMS AND OVERLAPS

- A. Sew all seams for geotextiles. Overlap geotextile 3 inches minimum prior to seaming. Do not seam horizontally on slopes steeper than 10 percent (i.e., seam along, not across slopes). All seams shall be either "double prayer" or "single J" seam.
- B. Ensure that no soil materials are inadvertently inserted beneath the seams of geotextiles.
- C. Sew with polymeric thread having chemical resistance and strength properties equal to or exceeding those of geotextile.
- D. For sewing, use a 401 two-thread chain stitch, or equivalent.

3.05 REPAIRS

- A. Repair holes or tears in geotextiles with a patch from the same geotextile material, sewn in place with a minimum seam overlap of 12 inches in all directions. Sew the geotextile within 1 inch of the outside edge of the patch materials. If tear exceeds 50 percent of the

roll width, remove and replace the roll. No patches will be allowed within 1 inch of a panel edge.

- B. Remove any soil or other material which may have penetrated the geotextile.
- C. Notify OWNER of all repairs for inspection and acceptance.

3.06 FIELD CONSTRUCTION QUALITY ASSURANCE (CQA)

- A. The OWNER will perform CQA testing prior and during geotextile installation in accordance with the CQA Plan.
- B. Cooperate fully with the OWNER in obtaining samples and performing tests and inspections. Include all costs for assistance in unit prices for work.

3.07 ACCEPTANCE

- A. INSTALLER retains all ownership and responsibility for geotextiles until acceptance by OWNER.
- B. OWNER accepts geotextiles when all the following have been completed:
 - 1. The installation is complete.
 - 2. Conformance tests verify product specifications.
 - 3. Documentation of installation is complete including the CQA Organization's final report.
 - 4. Verification of the adequacy of all seams and repairs, including associated testing, is complete.
 - 5. Written certification and warranty documents have been received by the OWNER.

3.08 EQUIPMENT

- A. No equipment shall be driven directly over geosynthetics. A minimum thickness of 1 ft (300 mm) of material is required between a low ground pressure (LGP) dozer and underlying geosynthetics such as a Caterpillar D4H LGP or equivalent. A minimum thickness of 3 ft of material is required between rubber-tired vehicles and underlying geosynthetics. In areas of heavy vehicle traffic, such as access ramps, the material thickness should be at least 3 ft. The following table shall be complied with during construction:

Maximum Equipment Ground Pressure (psi)	Initial Lift Thickness (ft)
5	1.0
10	1.5
20	2.0
>20	>3.0

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

**SECTION 02779
LLDPE GEOMEMBRANE**

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Furnishing all labor, materials, tools, supervision, transportation, and installation equipment necessary for the installation of linear low density polyethylene (LLDPE) geomembrane (AGRU Super Gripnet[®]), including providing boots around landfill gas (LFG) wells in the final cover system, as specified herein, as shown on the Construction Drawings.
- B. The CONTRACTOR is responsible for coordinating the deployment of LLDPE geomembrane with other portions of the Work.
- C. The Geosynthetic INSTALLER shall be prepared to install the LLDPE geomembrane in conjunction with the earthwork and other components of the final cover system.

1.02 RELATED SECTIONS

- A. Section 02225 – Subgrade Preparation
- B. Section 02249 – Earthfill
- C. Section 02227 – Granular Drainage Material
- D. Section 02771 – Geotextile
- E. Section 02800 – Interface Testing Program

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan
- B. Latest version of the ASTM International standards:
 - 1. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
 - 2. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
 - 3. ASTM D1004 - Standard Test Method of Tear Resistance Grades Tear of Plastic Film and Sheeting
 - 4. ASTM D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
 - 5. ASTM D1505 - Standard Test Methods for Density of Plastics by the Density-Gradient Technique
 - 6. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics
 - 7. ASTM D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
 - 9. ASTM D4716 - 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 D4833 - Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
 - 11. ASTM D5321 - Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
 - 12. ASTM D5397 - Standard Test Method for Evaluation of Stress Crack Resistance

- 13. of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
ASTM D5596 - Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
 - 14. ASTM D5641 - Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
 - 15. ASTM D5820 - Standard Practice for Pressurized Air Channel Evaluation of Dual-Seamed Geomembranes
 - 16. ASTM D5994 - Standard Test Method for Measuring Core Thickness of Textured Geomembranes
 - 17. ASTM D6392 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
 - 18. ASTM D6693 - Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
 - 19. ASTM D7466 - Standard Test Method for Measuring Asperity Height of Textured Geomembranes
- C. Geosynthetics Research Institute (GRI) Standards.
- 1. Test Method GM17 – Test Methods, Test Properties, Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
 - 2. Test Method GM19 - Seam Strength and Related Properties of Thermally Bonded Homogeneous Polyolefin Geomembranes/Barrier

1.04 SUBMITTALS

- A. The MANUFACTURER shall submit at least 21 calendar days prior to production of LLDPE geomembrane the following information:
- 1. Manufacturing capabilities, including:
 - a. daily production capacity available for this Contract;
 - b. manufacturing quality control procedures; and
 - c. list of material properties, including test results, to which are attached liner samples.
 - 2. The MANUFACTURER shall provide a list of completed projects where the proposed geomembrane has been installed. The following information shall be provided for each project:
 - a. name, location, type of facility (e.g. landfill cap), and date of installation;
 - b. names of OWNER, General CONTRACTOR, and INSTALLER; and
 - c. thickness and surface area of geomembrane supplied and installed.
 - 3. Origin (resin supplier's name, resin production plant) and identification (brand name, number) of the polyethylene resin to be used for this project.
- B. At least 21 calendar days prior to shipment any geomembrane to the site, the MANUFACTURER shall submit the following documentation on the geomembrane produced for this project.
- 1. Resin
 - a. Copies of quality control certificates issued by the resin supplier including the production dates and origin of the resin used to manufacture the geomembrane for the project.
 - b. Results of tests conducted by the Geomembrane MANUFACTURER to

verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project and the origin of the resin and quality control certificates issued by the resin supplier.

- c. Certification that no reclaimed polymer is added to the resin during the manufacturing of the geomembrane to be used for this project. If recycled polymer is used, the MANUFACTURER shall submit a notarized certificate signed by the production manager documenting the quantity of recycled material, including a description of the procedure used to measure the quantity of recycled polymer.
2. Geomembrane
 - a. Manufacturing certificates for each shift's production of LLDPE geomembrane, signed by responsible parties employed by the Geomembrane MANUFACTURER (such as the production manager).
 - b. The quality control certificate shall include:
 - i. roll numbers and identification;
 - ii. results of quality control tests, including descriptions of the test methods used.
 - c. The Geomembrane MANUFACTURER quality control tests to be performed are outlined in Part 2.3 of this Section.
 - d. The MANUFACTURER's warranty specified in Part 1.06 of this Section.
- C. At least 21 calendar days prior to mobilization of the Geosynthetic INSTALLER to the site, the INSTALLER shall submit the following information.
1. A drawing showing the installation layout identifying geomembrane panel configurations, dimensions, details, locations of seams, as well as any variance or additional details which deviate from the Construction Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. The layout drawings, as modified and/or approved by the OWNER, shall become part of these specifications.
 2. Installation schedule.
 3. Copy of INSTALLER's letter of approval or license by the Geomembrane MANUFACTURER.
 4. Installation capabilities, including:
 - a. information on equipment proposed for this project;
 - b. average daily production anticipated for this project; and
 - c. quality control procedures.
 5. A list of completed facilities for which the INSTALLER has installed polyethylene geomembrane. The following information shall be provided for each facility:
 - a. the name and purpose of the facility, its location, and dates of installation;
 - b. the names of the OWNER, General CONTRACTOR, GEOMEMBRANE, and the name and phone number of a contact at the facility who can discuss the project;
 - c. thickness and surface area of installed LLDPE geomembrane; and
 - d. type of seaming and type of seaming apparatus used.
 6. Resume of the superintendent to be assigned to this project, including dates and duration of employment.

7. Resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment.
8. The installation crew shall have the following experience.
 - a. The superintendent shall have supervised the installation of a minimum of 2,000,000 ft² (185,800 m²) of polyethylene geomembrane and 500,000 ft² (46,450 m²) of geotextile.
 - b. At least the seamer shall have experience seaming a minimum of 100,000 lineal ft (30,500 m) of polyethylene geomembrane seams using the same type of seaming apparatus to be used at this site. Seamers with such experience will be designated "master seamers" and shall provide direct supervision over less experienced seamers.
 - c. All other seaming personnel shall have seamed at least 10,000 lineal ft (3,000 m) of polyethylene geomembrane seams using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 10,000 lineal ft (3,000 m) of seams shall be allowed to seam only under the direct supervision of the master seamers or Superintendent.
- E. A Certificate of Calibration less than 12 months old shall be submitted for the field tensiometer prior to installation of any geomembrane.
- F. During installation, the INSTALLER shall be responsible for the timely submission to the CQA Organization of:
 1. Quality control documentation; and
 2. Subgrade acceptance certificates, signed by the INSTALLER, for each area to be covered by the geomembrane.
- G. On a monthly basis, the INSTALLER shall provide OWNER with up-to-date panel layout drawings. No partial payment will be made until an accurate, up-to-date panel layout is received by OWNER and deemed adequate by OWNER.
- H. Upon completion of the installation, the Geosynthetics INSTALLER shall be responsible for the submission to the OWNER of a warranty as specified in Part 1.06 of this Section.

1.05 QUALIFICATIONS

- A. Geomembrane MANUFACTURER
 1. The Geomembrane MANUFACTURER shall be responsible for the production of geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to provide material meeting the requirements of this section and the construction schedule for this project.
- B. Geomembrane INSTALLER
 1. The INSTALLER shall be responsible for field handling, deploying, seaming, temporarily restraining (against wind), and other site aspects of the geomembranes and other components of the liner system. The INSTALLER may also be responsible for anchoring systems and dewatering the area of installation including anchor trenches.

1.06 WARRANTY

- A. The Geomembrane MANUFACTURER shall furnish the OWNER a 20-year written warranty against defects in materials. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the OWNER.

- B. The Geomembrane INSTALLER shall furnish the OWNER with a 2-year written non-pro rata warranty against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the OWNER.

PART 2 PRODUCTS

2.01 RESIN

- A. The geomembrane shall be manufactured from new, first-quality polyethylene resin. Reclaimed polymer shall not be added to the resin; however, the use of polymer recycled during the manufacturing process shall be permitted if performed with appropriate cleanliness and if the recycled polymer does not exceed 2% by weight of the total polymer weight.
- B. The resin shall comply with the following LLDPE specified properties:

1. Specific Gravity:	0.915 minimum (ASTM D792 Method B, or ASTM D1505)
2. Melt Flow Index:	1.0 g/10 min., maximum (ASTM D1238 Condition E, 190°C, 2.16 kg)

2.02 GEOMEMBRANE PROPERTIES

- A. The Geomembrane MANUFACTURER shall furnish geomembrane having properties tested under Table 02779-1 that comply with the required property values shown in Table 02779-2.
- B. In addition to the property values listed in Table 02779-2, the geomembrane shall:
 - 1. Contain a maximum of 1% by weight of additives, fillers, or extenders (not including carbon black).
 - 2. Not have striations, pinholes (holes), bubbles, blisters, nodules, undispersed raw materials, or any sign of contamination by foreign matter on the surface or in the interior.
- C. The AGRU Super Gripnet® LLDPE geomembrane shall be textured on one side, and the other side shall have studs so that along with an overlying geotextile the geomembrane will perform as drainage material; the minimum requirements, including transmissivity, are listed in Table 02779-2.
- D. The following products are pre-qualified for the Work specified herein:
 - 1. 60-mil (1.5-mm) thick Super Gripnet® LLDPE geomembrane textured at the bottom and with stud on top manufactured by:
 AGRU America, Inc.
 500 Garrison Road
 Georgetown, SC 29440
 Phone: 800-373-2478

2.03 MANUFACTURING QUALITY CONTROL (MQC)

- A. Resin:
 - 1. The Geomembrane MANUFACTURER shall sample and test the resin to demonstrate that the resin complies with the Specifications. The Geomembrane MANUFACTURER shall certify in writing that the resin does meet the Construction Specifications and shall be held liable for any non-compliance.
 - 2. Any geomembrane manufactured from non-complying resin shall be rejected.

3. The Geomembrane MANUFACTURER shall comply with the submittal requirements of Part 1.04 of this Section.
- B. Rolls:
1. The Geomembrane MANUFACTURER shall continuously monitor geomembranes during the manufacturing process for defects.
 2. No geomembrane shall be accepted which exhibits any defects.
 3. The Geomembrane MANUFACTURER shall measure the geomembrane thickness at regular intervals along the roll length.
 4. No geomembrane shall be accepted, which fails to meet the specified thickness.
 5. The Geomembrane MANUFACTURER shall sample and test the geomembrane, at a minimum, once every 100,000 ft² (9,300 m²) per lot/batch to demonstrate that its properties conform to the values specified in Table 02779-2. As a minimum, the following tests shall be performed (Table 02779-1):

**Table 02779-1
LLDPE GEOMEMBRANE TEST METHODS**

Test	Procedure
Specific gravity	ASTM D1505/D792-Method B
Thickness	ASTM D5994
Yield strength	ASTM D6693
Yield elongation	ASTM D6693
Tensile strength	ASTM D6693
Tensile elongation	ASTM D6693
Carbon black	ASTM D1603/D4218
Carbon black dispersion	ASTM D5596
Puncture Resistance	ASTM D4833
Transmissivity	ASTM D4716

6. Any geomembrane sample that does not comply with the Specifications will result in rejection of the roll from which the sample was obtained and will not be used for this project.
7. If a geomembrane sample fails to meet the quality control requirements of this Section, the Geomembrane MANUFACTURER shall sample and test each roll manufactured, in the same resin batch, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.
8. Additional testing may be performed at the Geomembrane MANUFACTURER's discretion and expense, to isolate and more closely identify the non-complying rolls and/or to qualify individual rolls.
9. The following tests need not be run at the 1 per 50,000 ft² (4.650 m²) frequency but should be certified by the MANUFACTURER.

Test	Procedure
Environmental stress crack	ASTM D5397
Low temperature brittleness	ASTM D746

10. The Geomembrane MANUFACTURER shall comply with the submittal requirements of Part 1.04 of this Section.
- C. The Geomembrane MANUFACTURER shall permit the OWNER's REPRESENTATIVE to visit the manufacturing plant for project specific visits. If possible, such visits will be prior to or during the manufacturing of the geomembrane rolls for the specific project.

Table 02779-2
REQUIRED AGRU SUPER GRIPNET® LLDPE GEOMEMBRANE PROPERTY VALUES

PROPERTIES	QUALIFIERS	SPECIFIED UNITS	TEST VALUES	METHOD
Thickness (does not include textured surface)	Minimum	mils	60	ASTM D5994
Asperity Height	Lowest individual reading minimum	mils mil	54 18 for std or 130 & 175 for stud & spike for Gripnet®	ASTM D5994 ASTM D7466
Specific Gravity	maximum	N/A	0.939	ASTM D1505/D792
Melt Flow Index	maximum	g/10 min.	<1.0	ASTM D1238, Condition E (190°C, 2.16 kg)
Tensile Properties (each direction)				
1. Tensile Strength at Break (force per unit width)	minimum	lb/in.	126	ASTM D6693
2. Elongation at Break	minimum	%	300	ASTM D6693
Tear Resistance (Die C Puncture)	minimum	lb	40	ASTM D1004
Puncture Resistance	minimum	lb	70	ASTM D4833
Carbon Black Content	range	%	2 – 3	ASTM D1603/D4218
Carbon Black Dispersion	N/A	none	9 of 10 in Cat. 1 or 2, 1 in Cat. 3	ASTM D5596
Transmissivity (1)	minimum	m ² /s	6 x 10 ⁻⁴	ASTM D4716
Interface Shear Strength	minimum	psf	See Section 02800	ASTM D5321

1 – The transmissivity of the studded Agru Super Gripnet® LLDPE geomembrane and the overlying nonwoven 8 oz/sy geotextile is the hydraulic transmissivity of the drainage-side measured using water at 20°C ±1.5°C (68°F ±3°F) tested at hydraulic gradients of 0.25, 0.26, 0.286, and 0.33 under a normal load of not less than 350 psf. The properties for the nonwoven geotextile are in Section 02771. For the test, the drainage side (i.e., the stud side of the LLDPE geomembrane overlain by the nonwoven geotextile) shall be overlain by a layer of vegetative soil meeting the requirements in Section 02249 compacted to 85% of the maximum dry density and 3 percent above the optimum moisture content determined in general accordance with ASTM D1557. The soil below the spike side of the LLDPE geomembrane shall meet the requirements in Section 02249 for foundation layer and be compacted to 90% of the maximum dry density determined in general accordance with ASTM D1557. The minimum test duration shall be 100 hours and the report for the test results shall include measurements at intervals over the entire test duration.

2.04 LABELING

- A. Geomembrane rolls shall be labeled with the following information.
 - 1. thickness of the material;
 - 2. length and width of the roll;
 - 3. name of Geomembrane MANUFACTURER;
 - 4. product identification;
 - 5. lot number; and
 - 6. roll number.

2.05 TRANSPORTATION, HANDLING AND STORAGE

- A. Transportation of the geomembrane shall be the responsibility of the Geomembrane MANUFACTURER.
- B. Handling and care of the geomembranes prior to and following installation at the site shall be the responsibility of the Geomembrane INSTALLER. The Geomembrane INSTALLER shall be liable for all damage to the materials incurred prior to final acceptance of the final cover system by the OWNER.
- C. The Geomembrane INSTALLER shall be responsible for storage of the geomembrane at the site. The geomembrane shall be protected from excessive heat or cold, dirt, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Geomembrane MANUFACTURER shall be the INSTALLER's responsibility.

PART 3 EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the CONTRACTOR and Geomembrane INSTALLER shall become thoroughly familiar with all portions of the work falling within this Section.
- B. Inspection
 - 1. Prior to implementing any of the work in this Section, the CONTRACTOR shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse impact.
 - 2. If the Geomembrane INSTALLER has any concerns regarding the installed work of other Sections, he shall notify the OWNER in writing prior to the start of the work of this Section. Failure to inform the OWNER in writing will be construed as Geomembrane INSTALLER's acceptance of the related work of all other Sections.
 - 3. If the Geomembrane INSTALLER intends to install geomembrane between one hour before sunset and one hour after sunrise, he shall notify the Engineer and CQA Organization in writing prior to the start of the work. The Geomembrane INSTALLER shall indicate additional precautions, which shall be taken during these installation hours. The Geomembrane INSTALLER shall provide adequate illumination for work during this time period.

3.02 CONSTRUCTION QUALITY ASSURANCE (CQA)

- A. The installation of the LLDPE geomembrane shall be monitored and tested by the OWNER as outlined in the Construction Quality Assurance (CQA) Plan.

- B. The CONTRACTOR shall be aware of the activities in the CQA Plan and shall account for these CQA activities in the installation schedule.
- C. Cooperate fully with the OWNER in obtaining samples and performing tests and inspections. Include all costs for assistance in unit prices for work.
- D. Conformance Testing:
 - 1. Samples of the geomembrane will be removed by the CQA Organization and sent to a geosynthetics CQA Laboratory for testing to ensure conformance with the requirements of this Section. The CONTRACTOR shall account for this testing in the installation schedule. Only material, which meets the requirements of Part 2.02 or this section shall be installed.
 - 2. Samples will be selected by the CQA Organization in accordance with this Section and with the procedures outlined in the CQA Plan.
 - 3. Samples will be taken at a minimum frequency of **one sample per 100,000 ft² per lot/batch of manufactured geomembrane sheet.**
 - 4. The CQA Organization may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.03 of this Section. The additional testing shall be performed at the expense of the Geomembrane MANUFACTURER.
 - 5. As a minimum, tests shall be performed by the CQA Organization to establish the thickness, specific gravity, tensile properties, carbon black content, and carbon black dispersion of the geomembrane. The appropriate test methods are summarized in Table 02779-1.
 - 6. Any geomembranes that are not certified in accordance with Part 1.04 of this Section, or that conformance testing indicates do not comply with Part 2.02 of this Section, shall be rejected by the CQA Organization. The Geomembrane MANUFACTURER shall replace the rejected material with new material, at no additional cost to the OWNER.

3.03 GEOMEMBRANE DEPLOYMENT

- A. Layout Drawings
 - 1. The geomembrane INSTALLER shall deploy the geomembrane panel in general accordance with the submitted layout drawing. The layout drawing must be approved by the CQA Organization prior to installation of any geomembrane.
- B. Field Panel Identification
 - 1. A geomembrane field panel is a roll or a portion of roll cut in the field.
 - 2. Each field panel shall be given an identification code (number or letter-number). This identification code shall be agreed upon by the CQA Organization and geomembrane INSTALLER.
- C. Field Panel Placement
 - 1. Field panels shall be installed as approved or modified at the location and positions indicated in the layout drawings.
 - 2. Field panels shall be placed one at a time, and each field panel shall be seamed immediately after its placement.
 - 3. Geomembranes shall not be placed when the ambient temperature is below 40°F, unless otherwise authorized by the ENGINEER and the CQA Organization.

4. Geomembranes shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.
5. The CONTRACTOR shall ensure that the following conditions are met.
 - a. No vehicular traffic shall be allowed on the geomembrane.
 - b. Equipment used shall not damage the geomembrane by handling, trafficking, or leakage of hydrocarbons (i.e., fuels).
 - c. Personnel working on the geomembrane shall not smoke, wear damaging shoes, bring glassware, or engage in other activities which could damage the geomembrane.
 - d. The method used to unroll the panels shall not scratch or crimp the geomembrane and shall not damage the supporting soil.
 - e. The prepared surface underlying the geomembrane shall not be allowed to deteriorate after acceptance and shall remain acceptable up to the time of geomembrane placement.
 - f. The method used to place the panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).
 - g. Temporary ballast and/or anchors (e.g., sand bags), not likely to damage the geomembrane, shall be placed on the geomembrane to prevent uplift by wind.
 - h. The geomembrane shall be especially protected from damage in heavily trafficked areas.
 - i. Any rub sheets to facilitate seaming shall be removed prior to installation of subsequent panels.
6. Any field panel or portion thereof which becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material at no cost to the OWNER. Less serious damage may be repaired at the CQA Organization's option and at no cost to the OWNER. Damaged panels or portions of damaged panels which have been rejected shall be removed from the work area.

3.04 FIELD SEAMING

- A. Seam Layout
 1. In general, seams shall be oriented parallel to the line of maximum slope, (i.e., oriented down, not across, the slope). In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be less than 5 ft (1.5 m) from the toe of the slope, except where approved by the Engineer. No seams shall be located in an area of potential stress concentration. **In areas where new liner is tied to existing liner, the overlap shall be 2 ft (0.6 m) or as required to weld.**
- B. Personnel
 1. All personnel performing seaming operations shall be qualified as indicated in Part 1.04 of this Section. No seaming shall be performed unless a "master seamer" is on-site.
- C. Weather Conditions for Seaming
 1. Unless authorized in writing by the OWNER and the CQA Organization, seaming shall not be attempted at ambient temperatures below 40°F or above 104°F. A meeting will be held with the OWNER, CONTRACTOR, Engineer, and CQA

- Organization to establish acceptable installation procedures. In all cases, the geomembrane shall be dry and protected from wind damage.
2. If the Geosynthetics INSTALLER wishes to use methods which may allow seaming at ambient temperatures below 40°F or above 104°F, he shall use a procedure approved by the ENGINEER and the CQA Organization.
 3. Ambient temperatures shall be measured between 0 to 6 in. (0 to 150 mm) above the geomembrane surface.
- D. Overlapping and Temporary Bonding
1. Geomembrane panels shall be sufficiently overlapped for welding and to allow peel tests to be performed on the seam. Any seams which cannot be destructively tested because of insufficient overlap shall be treated as failing seams.
 2. The procedure used to temporarily heat bond adjacent panels together shall not damage the geomembrane. The temperature of the air at the nozzle of heat bonding apparatus shall be controlled such that the geomembrane is not damaged.
- E. Seam Preparation
1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.
 2. If seam overlap grinding is required, the process shall be completed according to the Geomembrane MANUFACTURER's instructions within 20 minutes of the seaming operation and in a manner that does not damage the geomembrane. The grind depth shall not exceed ten percent of the geomembrane thickness. Grinding marks shall not appear beyond 0.25 in. (6 mm) of the extrudate after it is placed.
 3. Seams shall be aligned with the fewest possible number of wrinkles and "fishmouths".
- F. General Seaming Requirements
1. Seaming shall extend to the outside edge of panels to be placed in the anchor trench.
 2. If required, a firm substrate such a flat board or similar hard surface may be placed directly under the seam overlap to achieve proper support.
 3. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is insufficient shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 in. (150 mm) beyond the cut in all directions.
 4. Any electric generator shall be placed outside the area to be lined or mounted in a manner which protects the geomembrane damage. The electric generator shall be properly grounded.
- G. Seaming Process
1. Seaming shall primarily be performed using fusion welding equipment and techniques. Use of extrusion welding takes place where fusion welding is not possible such as at pipe penetrations, patches, repairs and short (less than a roll width) runs of seams. Seaming equipment shall not damage the geomembrane. Only equipment identified as part of the approved submittal specified in Part 1.04 shall be used. Proposed alternate processes shall be documented and submitted to the OWNER's Representative for approval.
 2. Extrusion Equipment and Procedures
 - a. The Geosynthetics INSTALLER shall maintain at least one spare operable seaming apparatus on site.

- b. Extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle.
 - c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, the barrel shall be purged of all heat-degraded extrudate.
 - d. The Geosynthetics INSTALLER shall provide documentation regarding the welding rod or resin to the CQA Organization and shall certify that the welding rod or resin is compatible with the specifications and consists of the same resin as the geomembrane.
3. Fusion Equipment and Procedures
- a. The Geosynthetics INSTALLER shall maintain at least one spare operable seaming apparatus on site.
 - b. Fusion-welding apparatus shall be automated vehicular-mounted devices equipped with gauges giving the applicable temperatures and pressures.
 - c. The edges of cross seams shall be abraded to a smooth incline (top and bottom) prior to extrusion welding.
 - d. A movable protective layer may be used directly below each geomembrane overlap to be seamed to prevent the buildup of moisture between the sheets.

H. Trial Seams

- 1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Trial seams must be conducted on the same material to be installed and under similar field conditions as production seams. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours, for each seaming apparatus used that day. Also, each seamer shall make at least one trial seam each day. Trial seams shall be made under the same conditions as actual seams. The trial seam sample shall be a minimum of 15 ft (4.5 m) long by 1 ft wide (300 mm) (after seaming) with the seam centered lengthwise for fusion equipment and at least 3 ft (900 mm) long by 1 ft (300 mm) wide for extrusion equipment. Seam overlap shall be as indicated in Part 3.04.A.1 of this Section.
- 2. Four specimens, each 1 in. (25 mm) wide, shall be cut from the trial seam sample by the Geosynthetics INSTALLER. Two specimens shall be tested in shear and two in peel (inside and outside tracks for double fusion welds), using a tensiometer. The test specimens shall not fail in the seam. If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. A seamer may start production seaming prior to testing of the trial seams. In the event the trial seam fails, all production seams will be treated as failed seams and repaired in accordance with Part 3.0.K this Section at no additional cost to the OWNER.

I. Nondestructive Seam Continuity Testing

- 1. The INSTALLER shall nondestructively test for continuity on all field seams over their full length. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. The INSTALLER shall complete any required repairs in accordance with Part 3.04.K of this Section. The following procedures shall apply.
 - a. Vacuum testing shall be used for extrusion welds.

- b. Air pressure testing shall be used for double fusion seams.
 - c. Spark testing shall be performed if the seam cannot be tested using other nondestructive methods.
2. Vacuum Testing (ASTM D5641)
- a. The equipment shall comprise the following:
 - i. A vacuum box assembly consisting of a stiff housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.
 - ii. A system for applying 5 psi (34 kPa) gauge the box.
 - iii. A bucket of soapy solution and applicator.
 - b. The following procedures shall be followed:
 - i. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi (34 kPa) absolute gauge.
 - ii. Wet an area of the geomembrane seam larger than the vacuum box with the soapy solution.
 - iii. Place the box over the wetted area.
 - iv. Close the bleed valve and open the vacuum valve.
 - v. Ensure that a leak tight seal is created.
 - vi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than 30 seconds.
 - vii. If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. (75 mm) overlap, and repeat the process.
 - viii. All areas where soap bubbles appear shall be marked with a marker that will not damage the geomembrane and be repaired in accordance with Part 3.04.K of this Section.
3. Air Pressure Testing (ASTM D5820; For Double Fusion Seams Only)
- a. The following procedures are applicable to those processes which produce a double seam with an enclosed space.
 - b. The equipment shall comprise the following:
 - i. An air pump (manual or motor driven) or air reservoir, equipped with a pressure gauge, capable of generating and sustaining a pressure between 25 and 30 psi (172 and 207 kPa), mounted on a cushion to protect the geomembrane.
 - ii. A rubber hose with fittings and connections.
 - iii. A hollow needle, or other approved pressure feed device.
 - c. The following procedures shall be followed:
 - i. Seal both ends of the seam to be tested.
 - ii. Insert needle, or other approved pressure feed device, into the tunnel created by the fusion weld.
 - iii. Insert a protective cushion between the air pump and the geomembrane.
 - iv. Energize the air pump to a pressure between 25 and 30 psi (172 and 207 kPa), close valve, and sustain the pressure for not less than 5 minutes.
 - v. If loss of pressure exceeds 3 psi (20 kPa), or does not stabilize, locate

- faulty area and repair in accordance with Part 3.04.K of this Section.
- vi. Cut opposite end of air channel from pressure gauge and observe release of pressure to ensure air channel is not blocked.
 - vii. Remove needle, or other approved pressure feed device, and seal repair in accordance with Part 3.04.K of this Section.
- J. Destructive Testing (ASTM D6392)
1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive test sampling and testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.
 2. Sampling
 - a. Destructive test samples shall be collected at a minimum average frequency of one test location per 500 ft (150 m) of seam length. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The CQA Organization will be responsible for choosing the locations. The CONTRACTOR shall not be informed in advance of the locations where the seam samples will be taken. The OWNER or CQA Organization reserves the right to increase the sampling frequency.
 - b. Samples shall be cut by the INSTALLER at the locations designated by the CQA Organization as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered, and the sample number and location identified on the panel layout drawing. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately repaired in accordance with the repair procedures described in this Section. The continuity of the new seams in the repaired areas shall be tested according to this Section.
 - c. Two strips 1 in. (25 mm) wide and 12 in. (300 mm) long with the seam centered parallel to the width shall be taken from either side of the sample location. These samples shall be tested in the field in accordance with Part 3.04.3 of this Section. If these samples pass the field test, a laboratory sample shall be taken. The laboratory sample shall be at least 1 ft (300 mm) wide by 3.5 ft (1 m) long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:
 - i. One portion 1 ft (300 mm) long to the INSTALLER.
 - ii. One portion 1.5 ft (460 mm) long to the Geosynthetic CQA Laboratory for testing.
 - iii. One portion 1 ft (300 mm) long to the OWNER for archival storage.
 3. Field Testing:
 - a. The two 1 in. wide strips shall be tested in the tensiometer in the peel mode. Both inside and outside tracks shall be tested for double track fusion welds. The CQA Organization has the option to request an additional test in the shear mode. If any field test sample fails to meet the requirements in Table 02779-3, then the procedures outlined in Part 3.04.J.5 of this Section shall be followed.
 4. Laboratory Testing:

- a. Testing by the Geosynthetics CQA Laboratory will include "Shear Strength" and "Peel Adhesion" (ASTM D6392) with 1 in. wide strip, tested at a rate of 2 in. (50 mm) per minute. The minimum acceptable values to be obtained in these tests are those indicated in Table 02779-3. At least 5 specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear). Both inside and outside welds shall be tested for double track fusion welds.
5. Destructive Test Failure:
- a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the OWNER's laboratory, the Geosynthetics INSTALLER laboratory, or by a field tensiometer. The Geosynthetics INSTALLER shall have two options:
 - i. The geomembrane INSTALLER can reconstruct the seam (e.g., remove the old seam and re-seam) between any two passed test locations.
 - ii. The geomembrane INSTALLER can trace the welding path to an intermediate location, a minimum of 10 ft (3 m) from the location of the failed test (in each direction) and take a small sample for an additional field test at each location. If these additional samples pass the tests, then full laboratory samples shall be taken. These full laboratory samples shall be tested in accordance with Part 3.04.J of this Section. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed. In any case, all acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft (46 m) of reconstructed seam, a sample taken from within the reconstructed zone must pass destructive testing.
 - b. Whenever a sample fails, the CQA Organization may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.
- K. Defects and Repairs:
1. The geomembrane will be inspected before and after seaming for evidence of 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 inspection. The geomembrane surface shall be swept or washed by the INSTALLER if surface contamination inhibits inspection. The INSTALLER shall ensure that an inspection of the geomembrane precedes any seaming of that section.
 2. Each suspect location, both in seam and non-seam areas, shall be nondestructively tested using the methods described Part 3.04.I of this Section, as appropriate. Each location which fails nondestructive testing shall be marked by the CQA Organization and repaired by the INSTALLER.
 3. When seaming of a geomembrane is completed (or when seaming of a large area of a geomembrane is completed) and prior to placing overlying materials, the CQA Organization shall identify all excessive geomembrane wrinkles. The INSTALLER

shall cut and re-seam all wrinkles so identified. The seams thus produced shall be tested like any other seams.

4. Repair Procedures:

- a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the geomembrane INSTALLER. Several repair procedures exist. The final decision as to the appropriate repair procedure shall be agreed upon between the CQA Organization and the Geosynthetics INSTALLER. The procedures available include:
 - i. patching, used to repair large holes (and panel tee sections), tears, un-dispersed raw materials, and contamination by foreign matter;
 - ii. abrading and re-seaming, used to repair small sections of extruded seams;
 - iii. spot seaming, used to repair minor, localized flaws;
 - iv. capping, used to repair long lengths of failed seams;
 - v. topping, used to repair areas of inadequate seams, which have an exposed edge less than 4 in. (100 mm) in length; and
 - vi. removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).
- b. In addition, the following shall be satisfied:
 - i. surfaces of the geomembrane which are to be repaired shall be abraded no more than 20 minutes prior to the repair;
 - ii. all surfaces must be clean and dry at the time of repair;
 - iii. all seaming equipment used in repair procedures must be approved;
 - iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the CQA Organization;
 - v. patches or caps shall extend at least 6 in. (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in. (75 mm); and
 - vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Repair Verification:

- a. Each repair shall be nondestructively tested using the methods described in Part 3.04.I of this Section, as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests will require the repair to be redone and retested until a passing test results. At the discretion of the CQA Organization, destructive testing may be required on large caps.

3.05 MATERIALS IN CONTACT WITH THE GEOSYNTHETICS

- A. The CONTRACTOR shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation or during the installation of other components of the final cover system or by other construction activities.
- B. Granular materials shall not be placed on the geomembranes at ambient temperatures below 40°F or above 104°F. Unless otherwise noted, the maximum allowable height for a wrinkle shall be 6 in. (150 mm).
- C. Equipment shall not be driven directly on the geomembrane. Equipment shall be low ground

pressure equipment such as a Caterpillar D4H LGP or equivalent. Unless otherwise specified by the OWNER, all equipment used to spread and compact overlying fill shall comply with the following requirement:

Maximum Allowable Equipment Ground Pressure (psi)	Initial Lift Thickness of Soil Above Geosynthetics (ft)
5	1.0
10	1.5
20	2.0
>20	3.0

- D. In heavy traffic areas, such as access ramps, and in areas trafficked by rubber tire vehicles, the thickness of overlying compacted fill should be a least 3 ft (900 mm). Roads shall be at least twice the width of the largest piece of equipment.
- E. Appurtenances:
 - 1. Installation of the geomembrane in appurtenant areas, and connection of the geomembrane to appurtenances shall be made according to the Specifications and Drawings. Extreme care shall be taken while seaming around appurtenances since neither nondestructive nor destructive testing may be feasible in these areas. The INSTALLER shall ensure that the geomembrane has not been visibly damaged while making connections to appurtenances.
 - 2. All clamps, slips, bolts, nuts, or other fasteners used to secure the geomembrane to each appurtenance shall be at least as durable as the geomembrane.

3.06 GEOMEMBRANE ACCEPTANCE

- A. The geomembrane INSTALLER shall retain all ownership and responsibility for the geomembrane until accepted by the OWNER.
- B. The geomembrane shall be accepted by the OWNER when:
 - 1. the installation is completed;
 - 2. all documentation is submitted;
 - 3. verification of the adequacy of all field seams and repairs, including associated testing, is complete;
 - 4. all warranties are submitted; and
 - 5. written certification documents, including record drawings, sealed by the Engineer-of-Record have been received by the OWNER.

3.07 PRODUCT PROTECTION

- A. The geomembrane INSTALLER shall use all means necessary to protect all prior work and all materials and completed work of other Sections.
- B. In the event of damage, the geomembrane INSTALLER shall make all repairs and replacements necessary, to the approval of the CQA Organizations and at no additional cost to the OWNER.

**Table 02779-3
REQUIRED LLDPE GEOMEMBRANE SEAM PROPERTIES**

Properties	Qualifiers	Specified Units	Test Values⁽¹⁾	Method
Gauge	nominal	Mils	60	--
Hot Wedge Shear Strength ⁽²⁾	minimum	lb/in	90	ASTM D6392
Hot Wedge Peel Adhesion	minimum	lb/in	75	ASTM D6392
Extrusion Shear Strength	minimum	lb/in	90	ASTM D6392
Extrusion Peel Adhesion	minimum	lb/in	66	ASTM D6392

Notes:

1. Based on GRI Test Method GM19.
2. Also called "Bonded Seam Strength."

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

**SECTION 02800
INTERFACE TESTING PROGRAM**

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Interface shear testing using project-specific materials shall be performed by Construction Quality Assurance (CQA) Organization using the project-specific materials to validate assumptions for shear strengths used in engineering analyses.
- B. The Contractor shall be prepared to allocate sufficient time in his schedule for the required interface testing program prior to installing various liner components.
- C. Material suppliers and CONTRACTOR shall coordinate with OWNER for performing conformance testing, described in other sections of the Construction Specifications, and interface strength testing, in accordance with this Section, before delivery of material for installation. Conformance and interface test results shall be approved by OWNER before product shipment to the site.

1.02 RELATED SECTIONS

- A. Section 02249 – Earthfill
- B. Section 02771 – Geotextile
- C. Section 02779 – LLDPE Geomembrane

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan
- B. Latest (and applicable, depending on materials being tested) version of the ASTM International standards:
 - 1. ASTM D5321 - Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interface by Direct Shear
 - 2. ASTM D6243 - Standard Test Method for Determining the Internal and Interface Shear Strength of Geosynthetic Clay Liner by the Direct Shear Method
 - 3. ASTM D7466 - 10 Standard Test Method for Measuring Asperity Height of Textured Geomembranes

1.04 SUBMITTALS

[Not Used]

1.05 QUALIFICATIONS

- A. The interface testing program shall be performed by a qualified material testing laboratory, a well-established firm with more than 2 years of experience in interface testing and accredited under the Geosynthetic Institute (GSI, formerly Geosynthetic Research Institute, GRI).

PART 2 PRODUCTS

2.01 MATERIALS

- A. Materials used in the testing program shall be site/project-specific, collected by the OWNER at the project site or at the manufacturing plant.
- B. Testing of site-specific soil materials to be used in interface testing is also needed prior to performance of interface tests.
- C. The MANUFACTURER and/or the INSTALLER shall be responsible for providing the OWNER with appropriate materials to perform the tests at least 45 calendar days prior to shipment of materials to the site. Approval of the test results as passing by the OWNER is required prior to shipment.

PART 3 EXECUTION

3.01 TEST FREQUENCY

- A. Test frequency shall be one set of tests for each material interface described in Part 3.03. The Owner shall increase the frequency of testing in the event that test results do not comply with the requirements of these Construction Specifications.
- B. Interface shear test(s) shall be performed on the proposed geosynthetic and soil components in accordance with ASTM D5321 and/or D6243 to post-peak conditions. Tests shall be performed on several geosynthetic and soil interfaces as outlined in Part 3.03.

3.02 GENERAL TEST CONDITIONS

- A. Post-peak conditions are defined as the point at which the applied shear force remains constant with increasing shear displacement.
- B. The minimum post-peak shear displacement shall be 3 in. (75 mm).
- C. In testing, upper or lower boxes can be interchanged depending on the type of equipment.
- D. Submit to the OWNER, one each, 6 in. x 6 in. (150 mm x 150 mm) coupons of tested geosynthetics (e.g., geomembrane from the rolls of material that will be shipped to the site or were actually used for construction).
- E. Testing shall be performed such that orientation of materials being tested (i.e., which side is up) is consistent with orientation of installation in the field.
- F. The asperity of the geomembrane [ASTM D7466] used in testing shall be recorded and the data submitted with the test results.
- G. Samples of the geosynthetics used for testing shall be collected from rolls that will be shipped to the site or will be actually used for construction.
- H. The roll number of the geosynthetic, manufacturer, and description should be recorded on the data sheets.
- I. If correction factors are used to reduce the data, the factors should be indicated on the data sheets and the raw and corrected values should be reported by the testing laboratory.
- J. Each reportable value (e.g., asperity, stud height, texturing type, moisture content before and after tests, slip surface, damage observed to the various base liner system components such as rips, etc.) should be clearly labeled on the test data sheet.

3.03 MATERIAL-SPECIFIC CONDITIONS

Agru Super Gripnet® Geomembrane (GM) – spike side vs. Foundation Soil

- A. The test shall be conducted under hydrated conditions on materials meeting the requirements in these specifications. Perform the shear strength testing in accordance with ASTM D5321 and the following additional requirements:
1. Attach the site-specific LLDPE geomembrane (meeting the requirements of Section 02779 of these Specifications) to the lower box so that the spike side of the LLDPE geomembrane is in contact with the soil.
 2. Spray water over surface of geomembrane that will be in contact with the soil.
 3. Compact the soil material into the upper box to the minimum compaction in Section 02249 of the specifications and the highest possible moisture content in accordance with ASTM D1557 outside the machine (prior to placing the box over the geomembrane) using the compaction curve developed for the subgrade soil and place upper box over the geomembrane.
 4. Saturate under test normal stress for 16 hours.
 5. Use normal stress of 200 psf; 300 psf; and 400 psf.
 6. Shear at 0.04 in./min in accordance with ASTM D5321 to a large displacement of at least 3 inches or the point at which the applied shear force remains constant with increasing displacement, whichever is larger.
 7. For each normal load, the testing laboratory should report the interface where deformations are observed.
- B. The testing laboratory should report the interface where deformations are observed, the height of the geomembrane asperity [ASTM D7466], and any other observation on the behavior of the materials (e.g., ripping of the geotextile). The minimum required strengths are:

Agru Super Gripnet® Geomembrane (spikes) vs. Foundation Soil	
Normal Stress (psf)	Minimum Required Shear Strength at displacement of 3 inches (psf)
200	98
300	146
400	196

Agru Super Gripnet® Geomembrane (GM) – stud side vs. 8-oz/syd Nonwoven Geotextile (GT)¹

- A. The test shall be conducted under hydrated conditions only. Perform the shear strength testing in accordance with ASTM D5321 and the following additional requirements:
1. Attach the site-specific LLDPE geomembrane (meeting the requirements of Section 02779 of these Specifications) to the upper box so that the stud side of the LLDPE geomembrane is in contact with the geotextile.
 2. Spray the surface of the LLDPE geomembrane that will be in contact with the geotextile with water.
 3. Attach the site-specific geotextile (Section 02771) to the lower box and place the upper box over the geomembrane. **The nonwoven geotextile for the project shall not be heat-burnished.**
 4. For each normal load, apply the normal test load, keep the sample ends open, and flood the system with water for at least 1 hour.
 5. Use test normal stress of 200; 300; and 400 psf.
 6. Shear at 0.2 in./min per ASTM D5321.
- B. The testing laboratory should report the interface where deformations are observed, the height of the geomembrane studs, and any other observation on the behavior of the materials (e.g., ripping of the geotextile). The minimum required strengths are:

Agru Super Gripnet® Geomembrane (studs) vs. Nonwoven Geotextile	
Normal Stress (psf)	Minimum Required Shear Strength at displacement of 3 inches (psf)
200	98
300	146
400	196

END OF SECTION

¹ **The nonwoven geotextile for the project shall not be heat burnished.**