

APPENDIX C

TECHNICAL SPECIFICATIONS

Specifications

Section

02300	Earthwork for Liner Construction
02775	Geomembrane
02776	Geosynthetic Clay Liner (GCL)
02777	Drainage Composite
02778	Geotextile

Section 02300

Earthwork For Liner Construction

PART 1 - General

1.1 Summary

This section covers the work necessary to perform earthwork associated with construction of the landfill liner system. The work includes, but is not limited to, earthwork, excavating and removal of unsatisfactory soils and replacement with backfill material specified, clearing and grubbing, providing satisfactory material for fill and backfill as required, and soil placement and compaction.

1.2 Related Work

- A. The General and Supplementary Conditions of these specifications are a part of this section as if incorporated herein.
- B. Other related specification sections contained herein are as listed below:
 - 1. Section 02775, HDPE Geomembrane
 - 2. Section 02777, Drainage Geocomposite
 - 3. Section 02776, Geosynthetic Clay Liner
 - 4. Construction Quality Assurance Plan

1.3 Definitions

- A. "Relative compaction" is defined as the ratio, in percent, of the as-compacted field dry soil density to the laboratory maximum dry density as determined by the Standard Proctor Method, ASTM D 698. Corrections for oversize material may be applied to either the as-compacted field dry density or the maximum dry density, as determined by the ENGINEER.
- B. "Optimum moisture content" is defined as the moisture content corresponding to the maximum dry density obtained by the Standard Proctor test, ASTM D 698. Field moisture content shall be determined on the basis of the fraction passing the No. 4 sieve.
- C. "Completed course" is defined as a course or layer that is complete and ready for testing and/or the next layer or phase of construction.
- D. "Clearing" shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including down timber, snags, brush, and rubbish occurring in the areas to be cleared.
- E. "Grubbing" shall consist of the removal and disposal of stumps, roots, and matted roots from the designated grubbing areas.

1.4 Reference Standards

- A. Reference standards and recommended practices referred to herein shall be the latest revision of any such document.
- B. Standards referenced herein are as listed below:

1. ASTM D 422 Particle Size - Analysis of Soils
 2. ASTM D 448 Standard Sizes of Coarse Aggregate and Bridge Construction
 3. ASTM D 698 Moisture - Density Relations of Soils and Soil Aggregate Mixtures, Using a 5.5 lb Rammer and 12-Inch Drop
 4. ASTM D 1140 Amount of Material in Soils Finer than the No. 200 Sieve
 5. ASTM D 1556 Density of Soil in Place by the Sand - Cone Method
 6. ASTM D 1587 Thin-Walled Sampling of Soils
 7. ASTM D 2216 Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures
 8. ASTM D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)
 9. ASTM D 2937 Density of Soil In-Place by the Drive Cylinder Method
 10. ASTM D 3017 Moisture Content of Soil and Soil - Aggregate in Place by Nuclear Methods (Shallow Depth)
 11. ASTM D 4220 Preserving and Transporting of Soil Samples
 12. ASTM D 4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils
 13. ASTM D 5084 Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
 14. ASTM D 6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
 15. AWPA C 1 All Timber Products - Preservative Treatment by Pressure Processes Environmental Risk Assessment
 16. EPA 9100 Saturated Hydraulic Conductivity, Saturated Leachate Conductivity, and Intrinsic Permeability
- C. Florida Department of Transportation (FDOT) Standard Specifications for Road and Bridge Construction (Standard Specifications).

1.5 Quality Assurance, Acceptance and Tolerances

- A. Prior to commencing any excavation or grading, the CONTRACTOR shall satisfy himself as to the accuracy of all survey data as indicated on the drawings and in the specifications and/or as provided by the OWNER. Should the CONTRACTOR discover any inaccuracies, errors, or omissions in the survey data, he shall immediately notify the ENGINEER that proper adjustments can be anticipated or ordered. Commencement by the CONTRACTOR of any excavation or grading shall be held as an acceptance of the survey data by him after which time the CONTRACTOR has no claim against the OWNER resulting from alleged errors, omissions, or inaccuracies of the survey data.
- B. All grading shall be performed to strictly maintain slopes and drainage as shown on the drawings. Allowable tolerances are provided in Section 01050.

1.6 Submittals

Submittals shall be in sufficient detail to show full compliance with the specifications.

- A. Manufacturer's catalog data sheets for equipment scheduled for use in proof-rolling the subbase and for operating over geosynthetic layers shall be submitted.
- B. Certificates of compliance for proposed materials shall be submitted in accordance with at least 10 days before the material is required for use. Certificates of Compliance for all sources of soil materials shall clearly reference the source as described in paragraph 1.6F of this section.

C. SAMPLING AND TESTING

1. Tests required for location of an acceptable material source shall be done by an independent soils testing agency which shall be approved by the ENGINEER and retained by the CONTRACTOR. Certification for all materials indicating that the material conforms to the specification requirements along with copies of the test results from a qualified independent testing laboratory, approved by the ENGINEER and retained by the CONTRACTOR, shall be submitted to the ENGINEER for approval at least 10 days before the material is required for use. The CONTRACTOR shall coordinate material location and delivery with the testing agency and the ENGINEER. No materials shall be delivered to the site or used in construction until the proposed source and materials tests have been tentatively accepted in writing by the ENGINEER. The CONTRACTOR shall notify the ENGINEER, in writing, a minimum of 24 hours prior to the time materials approval is required.
2. Tests required for in-place final acceptance shall be performed by an independent testing agency as retained by the CQA Consultant. The number and location of the tests shall be as specified herein and as directed by the CQA Consultant throughout the project time period. The CONTRACTOR shall coordinate activity with the CQA Consultant and the testing agency to permit testing as directed in the presence of the CQA Consultant. The cost of any and all retests due to failure to achieve specified requirements are not included in the cost indicated in the Contract Documents, shall be invoiced to the CONTRACTOR separately, and shall be borne by the CONTRACTOR. All testing agency activities shall be performed under the direction and supervision of a Professional Engineer, licensed in the state of Florida.
3. Test results shall be sealed and signed by the testing agency representative who shall be a Professional Engineer, licensed in the state of Florida. Copies of test results shall be transmitted to the CQA Consultant in accordance with Section 01350. The reports shall include, as a minimum, project title; project location; location of sample, time, and date of testing or sampling; and test results.
4. The CONTRACTOR shall provide certification that proposed material is clean and meets gradation and other parameters herein specified. The following certification tests shall be performed at a minimum frequency of one per borrow source and/or change in material, except as noted.

Item	Test	ASTM No.
Structural Fill (Liner Subbase)	Soil Classification (USCS Classification System)	D 2487
	Sieve and Hydrometer Analysis	D 422
	Atterberg Limits	D 4318
	Natural Moisture Content	D 2216
	Standard Proctor	D 698
Protective cover layer (Sand Drainage Layer) (See Note 1)	Soil Classification (USCS Classification System)	D 2487
	Sieve and Hydrometer Analysis	D 422
	Atterberg Limits	D 4318
	Natural Moisture Content	D 2216
	Standard Proctor	D 698

Item	Test	ASTM No.
	Permeability of Granular Soils	D 2434
	Calcium Carbonate	D 3042
Low Permeability Soil	Soil Classification (USCS Classification System)	D 2487
	Sieve and Hydrometer Analysis	D 422
	Atterberg Limits	D 4318
	Standard Proctor	D 698
	Natural Moisture Content	D 2216
	Triaxial Permeability	D 5084
Leachate collection gravel	Soil Classification (USCS Classification System)	D 448
	Permeability of Granular Soils	D 2434
	Resistance to Degradation (LA Abrasion)	C 535
	Calcium Carbonate	D 3042
Topsoil	Soil Classification	D 2487
	Organic Content	D 2974
	pH	D 4972

Note: Testing for the protective cover layer shall be performed at a frequency of one per 3,000 cubic yards.

5. The CQA Consultant shall provide the following conformance tests during construction.

Item	Test	ASTM No.	Frequency
Structural Fill (Liner Subbase)	In-Place Density and Moisture Content	D1556, D2922, or D2937	Two per acre per lift; additional tests whenever there is a change in moisture conditions or apparent change in material type.
Low-Permeability Soil	In-Place Density and Moisture Content	D1556, D2922, or D2937	One per 500 LF of anchor trench per lift; additional tests whenever there is a change in moisture conditions, compaction technique or apparent change in material type.
Protective Cover layer prior to placement	Soil Classification (USCS Classification System) and Sieve Analysis	D3282, D422	Eight per 5,000 CY and additional tests whenever there is any apparent change in material.
	Permeability Tests of Granular Soils	D2434	Four per 10,000 CY and additional tests whenever there is any apparent change in material.

6. Classification tests on all materials as specified herein shall be made on samples of each material at its place of production prior to shipment. Classification tests in excess of those listed above may be required on the finished product if variation in gradation is apparent or if the material appears to depart from the specifications. Additional testing shall be as directed by the ENGINEER.

7. The soil material source will only be considered suitable if the hydraulic conductivity of the materials, as documented on laboratory test specimens, can be shown to meet the requirements of the project specifications at the 98% confidence level.
8. In-place density and moisture content shall be performed by the approved independent soil testing lab using the methods specified herein, or other methods selected by the CQA Consultant. The CONTRACTOR shall cooperate with this testing work by leveling small test areas designated by the CQA Consultant.
9. Final acceptance will be based on tests made on samples of material taken from the completed and compacted course. Acceptance will be made only on completed courses.
10. The OWNER and the CQA Consultant reserve the right to perform additional tests at the OWNER's expense of any material at any time, location, or elevation.
11. Any areas which do not meet compaction requirements shall be reworked, as necessary, to achieve the specified compaction and retested, at the OWNER's expense, to confirm that compaction requirements have been met.

PART 2 - PRODUCTS

2.1 PROTECTIVE COVER SOIL (SAND DRAINAGE LAYER)

- A. Sand shall be on-site/imported clean, excavated, natural sand, free from roots, sharp objects, or organic material, with a maximum size of 1/2 inch and 5% maximum by weight passing the No. 200 Sieve. The sand shall be classified as SW or SP by the Unified Soil Classification System. The sand drainage layer shall have a laboratory permeability not less than 1×10^{-3} cm/sec at 90% relative compaction (ASTM D 698). The material shall not be calcareous or of any other material that would interact with leachate. The sand shall be less than 10 percent loss of weight when tested in accordance with ASTM D3042 (Calcium Carbonate).

2.2 LEACHATE COLLECTION GRAVEL

- A. Gravel fill shall be imported, washed granite, FDOT No. 3 or 4 as approved by ENGINEER, free from roots, organic material and maximum size 2 1/2 inch with less than 5% by weight passing the 1/2-inch sieve. Leachate collection gravel will have a hydraulic conductivity of 1×10^{-1} cm/s (1×10^{-3} m/s) or greater. Material shall not be limerock or other material that would react and/or break down when in contact with solid waste leachate. The material shall not be calcareous or of any other material that would interact with leachate. The aggregate shall be less than 10 percent loss of weight when tested in accordance with ASTM D3042 (Calcium Carbonate).
- B. Aggregate shall be of sound, hard and durable quality. Aggregate shall have less than 15 percent loss when tested in accordance with ASTM C535. It shall not contain any soapstone, shale, or other material that easily disintegrates.

2.3 SUBGRADE

- A. Structural fill if needed shall be utilized to bring the subgrade to the final elevations indicated on the drawings from suitable on-site/off-site sources approved by the ENGINEER.



2.4 STRUCTURAL FILL AND SUBBASE

- A. Structural fill will be used for the subgrade, subbase and inter-cell berm as shown on the Drawings. The structural fill will consist of imported relatively homogenous natural soils that are free of debris, foreign objects, organics and other deleterious materials. Structural fill shall be classified according to ASTM D 2487 as GP-GM, GW-GM, GM, GW, SW-SM, SW, SP-SM, SP, SC or SM and will have no particles or soil clods larger than 4 in. (100 mm) except for the top 6 inches of the subbase. The maximum particle size within top 6-inches of subbase shall not exceed 0.5 in. (12 mm). Fill material shall be free from alkali, salt, petroleum products, roots, stones, rocks, and building debris. The structural fill shall be placed and compacted in lifts to the lines and grades shown on the Drawings. The compacted thickness of each lift will be 12 in. maximum (300 mm). Each lift will be compacted to at least 95 percent of the standard proctor maximum dry density (ASTM D698) within $\pm 3\%$ of optimum moisture content.

2.5 LOW-PERMEABILITY SOIL

- A. The low-permeability soil shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, excess silt, and organics. No particles larger than 0.75 inch shall be allowed. The soil shall be classified according to the Unified Soil Classification System (USCS, ASTM D 2487) as MH, ML, CL, or CH material. Regardless of the classification requirements, the material shall meet all of the requirements of this section. The selected soil shall not be gap-graded or susceptible to piping. Substandard materials shall be segregated at the source and will not be permitted at the work area. Any material that is found by the ENGINEER to be substandard shall be removed from the work area by the CONTRACTOR at no extra cost to the OWNER.
- B. The low permeability soil layers shall have a hydraulic conductivity of less than 1.0×10^{-6} cm/s tested in the laboratory in accordance with ASTM D 5084. The material shall be tested at an effective stress of 250 psf. The remolded sample shall be compacted to 95% of standard proctor compaction.

2.6 TOPSOIL

- A. The topsoil will be capable of promoting the growth of vegetation. The topsoil will be relatively homogenous natural soils that are free of debris, foreign objects, excess silt, clay lumps, brush, roots, weeds, or other deleterious materials. The topsoil will have at least 75 percent by weight passing the U.S. Standard No. 4 (4.75 mm) sieve, and at least 60 percent by weight passing the U.S. Standard No. 10 (2 mm) sieve. For the portion passing the U.S. Standard No. 10 (2 mm) sieve, the material will be classified as sandy loam, loam, or silt loam in accordance with the USDA classification system. In addition, the topsoil will have a pH in the range of 5.8 to 7; a minimum of 7 percent by weight of organic matter; and a maximum of 4 milliohms per centimeter of soluble salts. The material shall comply with the requirements of FDOT's Standard Specifications for Road and Bridge Construction (2004), Section 987 for Topsoil. If necessary, nutrients (including agricultural lime and fertilizer) shall be added to the topsoil to enhance its ability to promote vegetation growth. The ENGINEER shall be consulted prior to use of nutrients.



2.7 WATER AND MOISTURE CONTROL EQUIPMENT

- A. The CONTRACTOR shall provide water for compaction as necessary to achieve proper moisture conditions.
- B. Equipment for applying water shall be of a type and quality adequate for the work, shall not leak excessively, and shall be equipped with a distributor bar or other approved device to assure uniform application. Equipment for mixing and drying out material shall include blades, discs, or other approved equipment.

PART 3 - EXECUTION

3.1 EXCAVATION SAFETY AND LEGISLATION

- A. Protect bench marks and existing structures, roads, sidewalks, monitoring wells, piezometers, paving, and curbs against damage from equipment, vehicular or foot traffic, settlement, lateral movement, undermining, and washout.
- B. Install and maintain shoring, sheeting, bracing, and sloping necessary to support the sides of the excavation, to keep and to prevent any movement which may damage adjacent pavements, utilities, or structures; damage or delay the work; or endanger life and health. Install and maintain shoring, sheeting, bracing, and sloping as required by the Occupational Safety and Health Administration (OSHA) and other applicable governmental regulations and agencies.
- C. The CONTRACTOR shall be solely responsible for making all excavations in a safe manner. Excavations shall be barricaded and posted with warning signs for the safety of persons. Warning lights shall be provided during hours of darkness.
- D. Excavated materials suitable for backfill shall be piled in an orderly manner sufficiently distant from excavations to prevent overloading, slides, cave-ins, and obstruction of access ways and roadways.
- E. Underpin adjacent structure(s) which may be damaged by excavation work, including service lines.
- F. Notify ENGINEER of unexpected subsurface conditions and discontinue work in area until ENGINEER provides notification to resume work.
- G. Excavations shall be done in ways that will prevent surface and subsurface water from flowing into excavations and will also prevent flooding of the site and surrounding area.
- H. The CONTRACTOR shall familiarize themselves with, and comply with, all applicable codes, ordinances, and statutes, and bear sole responsibility for the penalties imposed for noncompliance.

3.2 TEMPORARY EROSION CONTROL

- A. It is the CONTRACTOR's responsibility to provide temporary erosion control procedures to protect slopes and other areas from erosion. Measures such as straw bales, temporary slope flumes, or other methods shall be used to protect completed work from damage due to erosion. Damage to facilities under construction, including clay liner, shall be repaired at the CONTRACTOR's sole expense.



3.3 REMOVAL OF WATER

- A. At all times during construction, CONTRACTOR shall provide and maintain proper equipment and facilities to remove all water entering the construction area so as to obtain satisfactory working conditions.
- B. Avoid settlement or damage to adjacent property. When dewatering open excavations, dewater from outside the structural limits and from a point below the bottom of the excavation when possible.
- C. Design dewatering system to prevent removal of fines from existing ground. CONTRACTOR shall comply with the facility Environmental Resource Permit for all discharges of groundwater to the stormwater conveyance system.
- D. The CONTRACTOR shall be responsible for the control and maintenance of groundwater and stormwater through all phases of construction. Under no circumstances shall stormwater be allowed to run into the excavation or pond therein. The CONTRACTOR shall prevent stormwater runoff from outside the Phase III - Area 4 limits (edge of liner) including, but not limited to, runoff from the existing active landfill cell entering the cell at all times during the construction and for the duration of the contract. The CONTRACTOR shall provide temporary stormwater control methods including berms, swales, ponds, and employ other such methods and devices to prevent stormwater runoff from entering and ponding in Area 4. Any work in the Area 4 area shall be coordinated with the OWNER 24 hours in advance of when needed. Ponded stormwater of any kind in Area 4 shall be pumped out of the cell and into the stormwater conveyance system within 24 hours of being identified.

3.4 SUBGRADE PREPARATION

- A. Heavy growths of grass and other vegetation, roots, debris, stones, objects larger than 2 inches in any dimension, and other materials undesirable to the subsurface construction shall be removed by mowing, grubbing, raking, or other methods from the surface of areas to be stripped.
- B. Stripping of the existing soil material in Area 4.
 - 1. The CONTRACTOR shall excavate 12 inches below the proposed top of cell floor subbase and 6 inches from the proposed final grades of cell sideslope subbase as shown in the grading plan. The excavated material is considered unsuitable for the 12-inch liner subbase.
 - 2. Excavated material shall be transported and stockpiled at the designated storage areas on site.
- C. Topsoil Stripping
 - 1. Topsoil shall be stripped from the surface of those areas to receive fills or embankments.
 - 2. Excavated topsoil shall be transported to, and stockpiled in, designated topsoil storage areas on site. Stripped topsoil may be used as topsoil for the Project if approved by the OWNER and ENGINEER.



D. Clearing Operations

1. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be completely removed except such trees and vegetation as may be indicated or directed to be left standing. Vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require. Clearing shall also include removal and disposal of structures that obstruct, encroach upon, or otherwise obstruct the work.

E. Grubbing Operations

1. The CONTRACTOR shall completely remove material to be grubbed, including logs, metallic and concrete, boulders debris, stumps, roots, and organic or other debris protruding through the ground surface.

F. Filling Depressions

1. Depressions resulting from grubbing operations shall be completely filled with acceptable backfilling material, unless further excavation or earthwork is required.
2. Prior to filling, subgrade surfaces of depressions shall be free of standing water. Unsatisfactory soil materials shall be removed.

3.5 SUBBASE PREPARATION

- A. The CONTRACTOR shall excavate and fill the subbase as required to achieve the subbase elevations indicated on the drawings. Fill shall be placed not to exceed 6-inch compacted lifts and shall be compacted to at least 95% of the Standard Proctor (ASTM D 698) maximum dry density, within $\pm 3\%$ of optimum moisture content. The subbase shall be proof-rolled with a vibratory drum roller. The CONTRACTOR shall provide the equipment and techniques necessary to produce a well-mixed, homogenous layer of the specified thickness, density, moisture content, and permeability. The subbase lifts shall not pump, rut, or crack under equipment loadings. Any subbase areas that show evidencing of "pumping" (when the clayey soil is over optimum moisture content) shall be remediated by waiting for it to dry, ripping, or discing the soil before re-compacting and testing.
- B. Upon completion of the compacted base by the CONTRACTOR, the double liner system shall be placed by CONTRACTOR in accordance with Section 02776 GCL, Section 02775, HDPE Geomembrane, and Section 02777, Drainage Geocomposite. The CONTRACTOR shall be responsible for maintaining moisture, density, and integrity of the completed compacted base. Any damage shall be repaired at the CONTRACTOR's sole expense.
- C. Exposure to construction traffic after completion of compacted base placement and compaction shall be minimized and shall include only equipment submitted to and approved by the ENGINEER. The GCL shall not be placed on saturated soil. Saturated subbase surfaces shall be aerated, dried back to acceptable moisture levels, and re-compacted immediately prior to installing the GCL.
- D. The CONTRACTOR shall sequence operations to allow for systematic completion of the liner system as soon as possible after compacted base completion.

3.6 LEACHATE COLLECTION GRAVEL AT LEACHATE COLLECTION/DETECTION PIPES

- A. Leachate drainage aggregate shall be placed in the trenches around leachate pipes as detailed on the Drawings. Leachate pipes shall be stabilized as necessary to prevent displacement or movement of piping during placement of aggregate backfill. Aggregate shall be placed in loose lifts and the leachate piping shall not be harmed or damaged during placement. Material shall be walked in and shall provide constant contact with and support to the pipe. Gravel shall be covered with geotextile filter as specified on the Drawings.

3.7 STRUCTURAL FILL AND LOW-PERMEABILITY SOIL

- A. CONTRACTOR shall place and compact structural fill to the lines and grades shown on the Drawings and as specified in this Section.
- B. Structural fill/low permeability soil shall be placed in lifts that results in a compacted lift thickness not more than 12-in. Anchor trenches shall be compacted with 2 passes using a walk-behind vibrating plate compactor.
- C. Each lift of structural fill and low permeability soil shall be compacted to at least 95 percent of the maximum dry unit weight determined from the standard Proctor compaction test (ASTM D 698). The soil material shall be compacted at moisture content within plus or minus 3 percent of the optimum moisture content.
- D. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Consultant will define the limits and nature of the defect. If the moisture content of the structural fill is outside of the acceptable range, the soil shall be wetted or dried as appropriate. Wetting shall be accomplished using a water truck and spray nozzle, unless the CQA Consultant approves an alternative method. During wetting or drying, the soil shall be regularly disced or otherwise mixed so that uniform moisture conditions are obtained.
- E. CONTRACTOR shall moisture-condition structural fill in either the stockpile area or work area. Any delays in progress due to moisture conditioning (wetting or drying) of soil, however, are the responsibility of CONTRACTOR.
- F. No structural fill shall be placed over a lift that has not been tested and approved by the CQA Consultant. Should the CQA tests indicate that the dry density of any layer of fill, or portion thereof is below the minimum acceptable value, the particular layer, or portion thereof, shall be reworked and recompacted at no cost to OWNER.

3.8 PROTECTIVE COVER LAYER (SAND DRAINAGE LAYER)

- A. Place protective cover layer in one lift with a minimum thickness as specified herein and as shown on the drawings. The CONTRACTOR shall exercise caution in keeping construction equipment off the geomembrane liner system. Provide sufficient thickness of protective cover layer to maintain the minimum specified thickness and to maintain the surface grades shown. The protective cover layer shall not be compacted or tested for compaction.



- B. Track-mounted equipment with low ground pressure treads (less than 6 psi), no larger than a Caterpillar Model D-6 or equal, shall be used for spreading. No tracked equipment shall be allowed to operate on less than 24 inches of cover over the geomembrane liner system. No other equipment, including dump trucks or scrapers, will be permitted to travel on the liner and sand layer. The CONTRACTOR shall avoid sharp turns, sudden starts or stops, spinning and digging of tracks, or any other operation that could damage the lining system. Articulated trucks are permitted to travel over the protective cover layer provided a minimum 4 foot thickness is maintained.
- C. The protective cover layer shall be placed in such a manner that no air is trapped underneath the lining. The CONTRACTOR shall provide and maintain a means of continuously observing the depth of the sand drainage layer, such as by freestanding markers at intervals of 50 feet maximum each way or other means as approved by the ENGINEER. Sharpened stakes shall not be allowed. Markers shall be removed after use and shall not be abandoned in-place.
- D. The CONTRACTOR shall take precautions necessary to preclude any damage to the liner system due to thermal expansion or contraction during all phases of liner construction and especially during placement of the protective cover layers.

3.9 TOPSOIL AND VEGETATION

- A. Unlined areas affected by construction shall be graded and seeded in accordance with the Contract specifications.
- B. The CONTRACTOR shall place topsoil to the lines and grades shown on the Drawings and as specified in this Section.
- C. The total thickness of the vegetative topsoil shall be a minimum of 6 in.
- D. Vegetative topsoil shall not be over compacted so that it inhibits growth of vegetation.
- E. CONTRACTOR shall moisture-condition vegetative topsoil in either the stockpile area or work area. Any delays in progress due to moisture conditioning (wetting or drying) of soil, however, are the responsibility of CONTRACTOR.
- F. No vegetative topsoil shall be placed over a lift that has not been tested and approved by the CQA CONSULTANT.

3.10 DISPOSAL OF EXCESS EXCAVATION

- A. Excavated materials shall be stored in area approved by OWNER and disposed at the active working face of the Class I Landfill North Cell as directed by the OWNER and ENGINEER. The OWNER will not apply a tipping fee for on-site disposal of wastes generated during construction.

3.11 GROUND PRESSURE RESTRICTIONS OVER GEOSYNTHETICS

- A. Equipment shall not be driven directly on geo-synthetics (e.g., GCL, geo-membrane, geotextile, geo-composite) at any time.
- B. Unless otherwise specified by ENGINEER, all equipment operating on earthen materials overlying geo-synthetics shall comply with the following:



<u>Allowable Equipment Overlying Pressure (psi)</u>	<u>Thickness of Compacted Soil (ft)</u>
<5	1.0
<10	1.5
<20	2.0
>20	3.0

END OF SECTION

Section 02775

HDPE Geomembrane

PART 1 - General

1.1 Summary

- A. Section Includes:
 - 1. Purchasing, delivery, installation, quality control, and testing of a HDPE geomembrane for a landfill bottom liner system.
- B. Related Sections include but are not necessarily limited to:
 - 1. Section 02300 – Earthwork for Liner Construction.
 - 2. Section 02777, Drainage Composite
 - 3. Section 02776, Geosynthetic Clay Liner
 - 4. Construction Quality Assurance Plan.

1.2 Quality Standards

- A. Referenced Standards:
 - 1. ASTM International (ASTM).
 - a. ASTM D638, Standard Test Method for Tensile Properties of Plastics.
 - b. ASTM D792, Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 - c. ASTM D1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
 - d. ASTM D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
 - e. ASTM D1603 Standard Test Method for Carbon Black in Olefin Plastics.
 - f. ASTM D3015 Standard Practice for Microscopic Examination of Pigment Dispersion in Plastic Compounds. Refer to Subpart 2.2 for property to be tested.
 - g. ASTM D3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.
 - h. ASTM D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
 - i. ASTM D4437 Determining the Integrity of Field Seam Used in Joining Flexible Polymeric Sheets of Geomembrane
 - j. ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
 - k. ASTM D5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
 - l. ASTM D5321, Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
 - m. ASTM D5397 Procedure to Perform a Single Point Notched Constant Tensile Load – Appendix (SP-NCTL) Test.

- n. ASTM D5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
- o. ASTM D5721 Practice for Air-Oven Aging of Polyolefin Geomembranes.
- p. ASTM D5820, Standard Practice for Pressured Air Channel Evaluation of Dual Seamed Geomembrane.
- q. ASTM D5885 Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
- r. ASTM D5994 Test Method for Measuring the Core Thickness of Textured Geomembranes.
- s. ASTM E-96-00, Procedure BW, Standard Test Methods for Water Vapor Transmission of Materials.
- 2. The Geosynthetic Research Institute (GRI).
 - a. GRI GM6 Pressurized Air Channel Test for Dual Seam Geomembranes.
 - b. GRI GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet.
 - c. GRI GM11 Accelerated Weathering of Geomembranes Using a Fluorescent UVA-Condensation Exposure Device.
 - d. GRI GM12 Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gauge.
 - e. GRI GM13 Standard Specification for Test Properties, Testing Frequency, and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembrane.
 - f. GRI GM14 Selection Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes.

B. Qualifications:

- 1. Each manufacturing and fabricating firm shall demonstrate 5 years continuous experience with a minimum of 10,000,000 SF of HDPE geomembranes.
- 2. INSTALLER:
 - a. Demonstrate 5 years continuous experience on at least 20 completed facilities with a minimum 10,000,000 SF of HDPE geomembranes.
 - b. Trained and certified by at least one of the named manufacturers in this Specification (not necessarily the manufacturer supplying materials for this Project).
 - c. Geomembrane INSTALLER Personnel Qualifications:
 - 1) Installation Superintendent shall have worked in a similar capacity on at least five HDPE geomembrane liner jobs similar in size and complexity to the project described in the Contract Documents.
 - 2) The Master Welder shall have completed a minimum of 5,000,000 sf of HDPE geomembrane seaming work using the type of seaming apparatus proposed for use on this Project.
 - 3) Other welders shall have seamed a minimum of 1,000,000 sf of HDPE geomembrane.
- 3. CQA Testing Laboratory shall demonstrate 3 years of continuous experience in geosynthetic materials testing similar to the testing contained herein.

C. Quality Assurance:

- 1. The OWNER or ENGINEER's representative will conduct independent testing to support construction quality assurance program and to provide documentation of such to appropriate regulatory agencies.

2. Unless specifically superseded by these contract documents or approved plans submitted by the CONTRACTOR, the geosynthetic materials shall be manufactured, stored, placed, seamed, tested and protected as described in EPA/600/R-93/182 and EPA/530/SW-91/051.
 - a. This specifically includes:
 - 1) Material Composition.
 - 2) Manufacturing.
 - 3) Handling and Packaging.
 - 4) Shipment.
 - 5) Storage (Manufacturer and Site).
 - 6) Placement:
 - a) Seaming and Joining.
 - b) Destructive and Non Destructive Testing.
 - c) Protection, Backfilling and Covering.
 - 7) Conformance Testing.
 - 8) Anchoring and Anchor Trenches.
 - 9) Access Roads/Ramps.
- D. CQA Plan Implementation: Construction Quality Assurance will be performed in accordance with the Specifications and permitted CQA Plan prepared for this project. The CONTRACTOR and Geomembrane INSTALLER should familiarize themselves with the CQA Plan.
- E. Certifications:
 1. Certifications are required for various aspects of the project related to the HDPE geomembrane liner system construction.
 - a. Unless alternately approved, the certificates provided at the end of this Section shall be used and no alterations, additions, deletions, or exception shall be made to the specified language.
- F. INSTALLER's construction quality control programs to include, but not be limited to, installation testing, including both nondestructive and destructive quality control field testing of the sheets and seams during installation of the geomembrane, proposed methods of testing geosynthetic joints and connections at appurtenances for continuity, documentation and changes, alterations, repairs, retests, and acceptance.
- G. Geomembrane INSTALLER's installation manual to include:
 1. Ambient temperature at which the seams are made
 2. Control of panel lift up by wind
 3. Acceptable condition of the subsurface beneath the geomembrane
 4. Quality and consistency of the welding material
 5. Proper preparation of the liner surfaces to be joined
 6. Cleanliness of the seam interface (e.g., the amount of airborne dust and debris present)
 7. Proposed details for connecting the HDPE liner to appurtenances, i.e. penetrations of the containment facilities.
 8. A complete description of seaming by extrusion welding and hot-wedge welding.
 9. Requirements of the MANUFACTURER's Installation Manual unless exceptions are noted and approved by the ENGINEER.

1.3 Definitions And Responsibilities

- A. Geomembrane MANUFACTURER: MANUFACTURER of geomembranes producing geomembrane sheets from resin and additives. The manufacturer is responsible for producing geomembrane sheet which complies with these Specifications. These responsibilities include but are not limited to:
1. Acceptance of the resin and additives from chemical formulators. Testing of the raw resin and additives to ensure compliance with the manufacturer's specifications and with this Specification.
 2. Formulation of the resin and additives into geomembrane sheeting using mixing and extrusion equipment.
 3. Testing of the geomembrane sheet to ensure compliance with manufacturer's specification and this Specification.
 4. Shipping of the geomembrane sheet to INSTALLER or ENGINEER designated facilities.
 5. Certification of the raw materials and finished geomembrane sheet to comply with this Specification.
 6. Certification of installer's training, experience, and methods for welding and inspection of geomembrane installations in compliance with manufacturer's standards.
- B. Geomembrane INSTALLER. INSTALLER of geomembranes is responsible for handling, fitting, welding, and testing of geomembrane sheets or blankets in the field. These responsibilities include but are not limited to:
1. Acceptance (in writing) of the geomembrane from the manufacturer.
 2. Acceptance (in writing) subbase followed by GCL surface layer will serve as a base for the geomembrane. This acceptance shall precede installation of the geomembrane, and shall state that the installer has inspected the surface, and reviewed the Specifications for material and placement, and finds all conditions acceptable for placement of geomembrane liners. The written acceptance shall explicitly state any and all exceptions to acceptance.
 3. Handling, welding, testing, and repair geomembrane liners in compliance with this Specification and the Geomembrane INSTALLER's Installation Procedures Manual.
 4. Performance of QC testing and record keeping as required by the approved Geomembrane INSTALLER's Field Installation Procedures Manual.
 5. Repair or replacement of defects in the geomembrane as required by the CQA Officer or the ENGINEER.
- C. Inspector:
1. Inspectors of HDPE geomembrane are the individuals responsible for observing field installation of the geosynthetic materials and providing the MANUFACTURER, INSTALLER, CQA Officer, and OWNER with verbal and written documentation of the compliance of the installation with this specification and with written procedures manuals prepared by the MANUFACTURER or INSTALLER.



- D. CQA Testing Laboratory shall:
 - 1. Perform conformance testing and destructive testing of the HDPE geomembrane.
- E. INSTALLER's QC Consultant: Responsible for observing field installation of the geomembrane and performance of material conformance and CQC testing to provide the CONTRACTOR with verbal and written documentation of the compliance of the installation with these Specifications. The CQC Consultant reports to the CONTRACTOR and is part of this contract.
- F. CQA Officer: Responsible for implementing CQA Plan including reviewing material conformance testing, review destructive testing, field installation of the geomembrane, and CQC activities, and to perform limited CQA conformance testing to provide OWNER with verbal and written documentation of the compliance of the installation with these Specifications. The CQA Officer will use the written results of the CQC program and the CQA program in the preparation of the Project Certification Document. The CQA Officer reports to the OWNER and is not part of this contract.
- G. Refer to the accompanying CQA Plan for additional definitions.

1.4 Submittals

- A. Shop Drawings:
 - 1. At least 14 days prior to installation submit for ENGINEER's approval Shop Drawings, including:
 - a. MANUFACTURER's certification that raw materials and sheet materials comply with required materials, mil thickness, and material properties. Original certificates are required.
 - b. MANUFACTURER/Fabricator/INSTALLER quality control requirements.
 - c. Qualifications and experience of key personnel per 1.2 B of this section.
 - d. MANUFACTURER's written acceptance of Geomembrane INSTALLER's qualifications for installation of the HDPE geomembrane.
 - e. HDPE Geomembrane panel layout plan with proposed size, number, position and sequencing of liner panels and showing the location and direction of all field or factory joints.
 - 1) Proposed details for connecting the geosynthetic materials to appurtenances.
 - 2) Proposed methods of welding, seaming or jointing geosynthetic materials.
 - 3) Proposed method and sequencing for placement of geocomposite on top of the HDPE geomembrane liner.
 - 4) Proposed method of testing HDPE geomembrane and other geosynthetic materials, joints and connections at appurtenances for continuity.
 - 5) Proposed details for anchor trench if different than included in Contract Documents.

B. Miscellaneous:

1. Test results:

- a. Resin test, tests of sheet material and factory seam tests at frequency specified in respective quality control manuals.
- 1) Results shall include or bracket the rolls delivered for use in the Work.
- b. Daily test seam results.
- c. Daily results of production seam testing.
- d. At least 14 days prior to geomembrane deployment, manufacturing quality control certificates for each shift's production shall be submitted. The certificates shall identify the origin of the resin and the manufacturer of geomembrane. The certificates shall be signed by responsible parties employed by the manufacture (such as the production manager). The quality control certificate shall include:
 - a. roll numbers and identification;
 - b. sampling procedures; and
 - c. results of quality control tests, including a description of the test methods used.
- e. At least 14 days prior to shipment of the geomembrane, leachate compatibility test data shall be submitted to ENGINEER.
- f. Warranties as described below.

2. Submit written certifications that:

- a. Utilize certification forms from this Section unless alternately approved. Make appropriate number of copies, as required.
- b. The HDPE geomembrane material delivered to site meets the requirements of this Specification.
- c. The HDPE geomembrane were received and accepted in undamaged condition from shipper.
- d. The subgrade has been properly prepared and acceptable for the placement of the HDPE geomembrane.
- e. The HDPE geomembrane liner was installed in accordance with this Specification, Project Drawings and with approved Shop Drawings.
- f. The HDPE geomembrane joints were inspected, tested for strength and continuity, and passed all inspections and tests.
- 1) All test and inspection data shall be incorporated into this certification.
- g. The geocomposite layer on top of the HDPE geomembrane liner was placed properly and carefully.

3. MANUFACTURER/INSTALLER's Field Installation Procedures Manual shall clearly identify any exceptions taken to the specified execution of the work.

4. At least 14 days prior to shipment of the geomembrane, recommendations for unloading, field handling, and stockpiling of the geomembrane shall be submitted.

5. During the installation, the Geosynthetics INSTALLER shall be responsible for the timely submission to the CQA Officer of:

- a. quality control documentation;
- b. panel layout with destructive tests, panel boundaries and repairs shown; and
- c. subgrade acceptance certificates, signed by the INSTALLER, for each area to be covered by the geomembrane



6. Record Drawings: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the identity and location of each repair, cap strip, penetration, boot, and sample taken from the installed geosynthetic for testing. The record drawings shall show locations of each type of material, anchor trenches and the construction baseline.
- C. Provide all submittals in a single coordinated transmittal. Partial submittals will not be accepted. All submittals must be submitted prior to the Geomembrane Preconstruction Meeting.

1.5 Delivery, Storage and Handling

- A. Unused or stockpiled HDPE geomembrane shall be stored in accordance with the manufacturer's recommendations.
- B. Each roll shall be labeled with the manufacturers name, type, lot number, roll number, and roll dimensions (length, width, gross weight).
 1. HDPE geomembrane or plastic wrapping damaged as a result of storage or handling shall be repaired or replaced, as directed.
 2. HDPE geomembrane shall not be exposed to temperatures in excess of 60 DegC (140 DegF) or less if authorized by the MANUFACTURER.
- C. No hooks, tongs or other sharp instruments shall be used for handling the HDPE geomembrane.
 1. Rolls shall not be lifted by use of cables or chains in contact with the HDPE geomembrane.
 2. HDPE geomembrane shall not be dragged along the ground.

1.6 Project Conditions

- A. When the weather is of such a nature as to endanger the integrity and quality of the installation, whether this is due to rain, high winds, cold temperatures, or other weather elements, the installation of the geomembrane shall be halted at the direction of, or with the concurrence of, the OWNER until the weather conditions are satisfactory.
- B. Ensure that adequate dust control methods are in effect to prevent the unnecessary accumulation of dust and dirt on geosynthetic surfaces which hamper the efficient field seaming of geosynthetic panels or performance.
- C. Maintain natural surface water drainage diversions around the work area and provide for the disposal of water which may collect in the work area directly from precipitation falling within the area or from inadequate diversion structures or practices.
- D. Coordinate the installation of the leachate collection system which shall be in accordance with Geomembrane INSTALLER's Installation Manual and as specified in these Specifications and shown on the Contract Drawings.
- E. Vehicles, other than those specifically approved, will not be allowed on HDPE membrane liner unless at least 24 inch of protective soil cover has been placed over these materials.
 1. No vehicle shall access the completed Work unless it can be demonstrated that its weight, movement or activities will not damage the Work.



2. When damage is suspected uncover area, repair damage if required, and recover area at no cost to OWNER.
3. Suspect areas may be identified by OWNER or ENGINEER.

1.7 Warranties

- A. Written warranties addressing HDPE geomembrane material and installation workmanship shall be furnished by the CONTRACTOR and shall be made to the OWNER.
- B. Submit material samples and warranties prior to shipment.

PART 2 - Products

2.1 Acceptable Manufacturers and or Geomembrane Installers

- A. Subject to compliance with the Contract Documents, the following manufacturers and installers are acceptable:
 1. HDPE Geomembrane liners manufacturers:
 - a. Agru/America, Inc.
 - b. GSE, Inc.
 - c. Poly-Flex Inc.
 2. HDPE Geomembrane Liner Installers:
 - a. Authorized installers of approved manufacturers.
 - b. Other installers may qualify by providing references for a minimum of 10,000,000 SF of liner installations.
- B. Submit requests for substitution to ENGINEER for approval.

2.2 Resin

- A. Reclaimed polymer shall not be added to the resin; however, the use of polymer recycled during the manufacturing process shall be permitted if approved by OWNER and ENGINEER and if the recycled polymer does not exceed 2 percent by weight of the total polymer weight. The geomembrane shall be manufactured from new, first-quality polyethylene resin, and shall be designed and manufactured specifically for use in geomembranes. No additives or fillers may be added to the resin prior to or during manufacture of the HDPE geomembrane.
- B. The resin shall comply with the following HDPE specified properties.
 1. Specific Gravity: 0.932 (ASTM D 792 Method A)
 2. Melt Index: 1.0 g/10 minute, maximum (ASTM D 1238 Condition E 190°C, 2.16 kg)

2.3 Materials

- A. HDPE Geomembrane Liner:
 1. Consists of unreinforced polyethylene.



2. Thickness: 60 mils for bottom liner.
 3. No additives or fillers may be added to the resin prior to or during manufacture of the HDPE geomembrane.
 4. Manufactured to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.
 - a. Any such defects shall be cause for rejection of the material.
 - b. Minor defects may be repaired in accordance with Section 3.2.
 5. Manufactured as seamless rolls.
 - a. Minimum width: 22 feet as delivered to the site.
 6. Prior to shipment, the geomembrane manufacturer will provide the CQA Officer and the INSTALLER's QC Consultant with a quality control certificate for each roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the geomembrane manufacturer and will include:
 - a. Roll numbers and identification; and
 - b. The results of quality control tests performed under the MQC program.
 7. The INSTALLER's QC Consultant will verify that a control certificate has been received for each roll and that the certified roll properties meet the requirements of these Specifications.
 8. HDPE sheet with texture on both sides shall be used for the primary and secondary geomembranes.
- B. Manufacturing Quality Assurance (QA): The geomembrane liner shall be manufactured in accordance with a written quality assurance/quality control program (QC). This QA/QC program shall be submitted to the ENGINEER or CQA Consultant, together with shop drawings showing the layout of geomembrane liner in the containment facility. After this QA/QC program has been approved by the ENGINEER or CQA Consultant, the MANUFACTURER shall not deviate from the program without written approval of the ENGINEER or CQA Consultant. The geomembrane liner material shall meet or exceed GRI GM13 and the following requirements:

Item	ASTM Test Method	Test Value	Min. Test Frequency	
			MQC	CQA
Density (Resin)	D1505	>0.932 g/cc	1/180,000 lb	---
Sheet Thickness (Note 1) <ul style="list-style-type: none"> Minimum Average Lowest Individual 8 of 10 Lowest Individual 10 of 10 	D5994	60 mil nominal - 5% nominal - 10% nominal - 15%	1/50,000 ft ²	1/100,000 ft ²
Asperity Height, Minimum Average	GRI GM12	10 mil	1/45,000 ft ²	---
Sheet Density (min. ave.)	D1505	≥ 0.940 g/cc	1/180,000 lb	1/100,000 ft ²
Melt Flow Index (Resin) (g/10 min.)	D1238 Condition 190/2.16	≤ 1.00	1/200,000 ft ²	---
Minimum Tensile Properties <ul style="list-style-type: none"> Yield Stress Break Stress Elongation at Yield Elongation at Break (2-inch gage length) 	D638, Type IV, Dumb-bell at 2 imp. (each direction) or ASTM D6693	126 ppi 90 ppi 12% 100%	1/20,000 ft ²	1/100,000 ft ²
Min. Tear Resistance Initiation	D1004, Die C	42 lbs	1/45,000 ft ²	---



Carbon Black Content	D1603 or D4218	2.0-3.0%	1/20,000 ft ²	1/100,000 ft ²
Carbon Black Dispersion	D5596	Category 1 or 2	1/45,000 ft ²	1/100,000 ft ²
Puncture Resistance, Minimum Average	D4833	90 lbs	1/45,000 ft ²	---
Dimensional Stability	D1204	+/- 3.0%	1/lot	---
Oxidative Induction Time, Minimum Average	D3895 or D5885	100 min. 400 min.	1/lot, and 1/200,000 lb	---
Asperity Height, Minimum Average	GRI GM12	10 mil	1/45,000 ft ²	---
Max. Water Vapor Transmission Rate	E96	0.24 g/m ² per day	1/lot	---
Stress Crack Resistance	D5397	200 hr	1/lot	---

Notes:

1. Thickness shall be monitored continuously through the manufacturing process, or measured physically at a frequency of not less than one per roll of manufactured geomembrane.
 2. Routine testing of fabricated seams, where applicable, shall include seam shear strength and seam peel strength at a frequency of not less than one per 500 liner feet of seam. The Fabricator shall test all seams using one of the methods specified in Paragraph 3.2.C.2.
- C. Extrusion rod shall be manufactured from identical resin to that used in geomembrane manufacture. Manufactured extrusion rod shall be tested for carbon black, specific gravity and melt index at a frequency of not less than one test per batch.
- D. The MANUFACTURER shall reject resin shipments which do not conform with the density and melt index requirements of the approved QA/QC program. The MANUFACTURER shall reject manufactured geomembrane which does not conform to the sheet physical requirements of the approved QA/QC program. The MANUFACTURER shall reject fabricated seams, where applicable, which do not exhibit seam shear strength of greater than 120 lbs per inch of width, and seam peel strength of greater than 90 lbs per inch of width.

2.4 Manufacturing Quality Control

- A. Resin:
1. The MANUFACTURER shall sample and test the resin to demonstrate that the resin complies with the Specifications. The MANUFACTURER shall certify in writing that the resin meets the Specifications, and shall be held liable for any non-compliance.
 2. Any geomembrane manufactured from non-complying resin shall be rejected.
 3. Conformance testing, as defined in Part 2.7 of this Section and in the CQA Plan, will be carried out by the CQA Officer. If the MANUFACTURER's and CQA Officer's test results differ, the tests will be repeated by the CQA Officer, and the MANUFACTURER will be allowed to monitor this testing. The results of this latter series of tests will prevail, provided that the applicable test methods, as detailed in the CQA Plan, have been followed.

B. Rolls:

1. The MANUFACTURER shall continuously monitor geomembranes during the manufacturing process for inclusions, bubbles, or other defects.
2. The MANUFACTURER shall continuously spark test geomembranes during the manufacturing process to confirm that no defects were found.
3. No geomembrane shall be accepted that exhibits any defects.
4. The MANUFACTURER shall continuously monitor the geomembrane thickness during the manufacturing process.
5. No geomembrane shall be accepted that fails to meet the specified minimum thickness.
6. The MANUFACTURER shall sample and test the geomembrane, at a minimum, test frequencies specified in GRI Test Method GM13, subject to any revisions.
 - a. Samples taken from stored rolls shall be taken across the entire width of the roll and shall not include the first wrapping or outer layer of the roll (about 3.3 feet).
 - b. Samples taken at the time of manufacturing can be obtained from the end of the roll.
 - c. Unless otherwise specified, samples shall be 2 feet long by the roll width. The MANUFACTURER shall mark the machine direction on the samples with an arrow.
7. Any geomembrane sample that does not comply with the Specifications will result in rejection of the roll from which the sample was obtained. CONTRACTOR shall replace any rejected rolls at no additional cost to OWNER.
8. If a geomembrane sample fails to meet the quality control requirements of this Section, the 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.
9. Additional testing may be performed at the MANUFACTURER's discretion and expense, to more closely identify the non-complying rolls and/or to qualify individual rolls.

2.5 Equipment And Accessories

A. Welding and Seaming Equipment:

1. Equipped with gages showing temperatures at the nozzle (extrusion welder) or at the wedge (wedge welder).
2. Maintained in adequate numbers to avoid delaying work.
3. Supplied by a power source capable of providing constant voltage under a combined-line load.
4. Electric generator shall not be placed directly on the HDPE geomembrane.

B. Field Tensiometer:

1. Provide a tensiometer for on-site shear and peel testing of HDPE geomembrane seams.
 - a. Tensiometer shall be in good working order.
 - b. Built to ASTM specifications.



- c. Accompanied by evidence of calibration of equipment and gages within the past six months. The evidence of calibration shall be submitted to the CQA consultant.
- 2. Tension meter:
 - a. Motor driven.
 - b. Jaws capable of traveling a measure rate of 2 inch per minute.
 - c. Equipped with a gauge that measures the force in unit pounds exerted between the jaws.
 - d. Digital readout.
- C. Punch Press:
 - 1. Provide a punch press for the onsite preparation of specimens for testing.
 - 2. Capable of cutting specimens in accordance with ASTM D4437.
- D. Vacuum Box:
 - 1. Provide a vacuum box for onsite testing of HDPE geomembrane seams in accordance with ASTM D5641.
- E. Equipment necessary to perform "Pressurized Air Channel Evaluation of Dual Seamed Geomembranes" in accordance with ASTM D5820.
- F. Gages:
 - 1. Calibrated within past six months.
 - 2. Specified test values reading near mid-range of the gage scale.

2.6 Manufacturer's Responsibilities

- A. The MANUFACTURER is responsible for producing geomembrane sheet that complies with this Specification. These responsibilities include but are not limited to:
 - 1. Resin and additive quality control:
 - a. Acceptance of the resin and additives from chemical formulators.
 - b. Testing of the raw resin and additives to ensure compliance with the MANUFACTURER's specifications and with this Specification.
 - 2. Formulation of the resin and additives into sheeting using mixing and extrusion equipment.
 - 3. Testing of the sheet material to ensure compliance with MANUFACTURER's specifications and this Specification.
 - 4. Shipping of the sheet material to INSTALLER.
 - 5. Certification of the raw materials and finished sheet to comply with this Specification.
 - 6. Certification of INSTALLER's training (unless INSTALLER is certified by other acceptable manufacturer list herein), experience and methods for welding, seaming, joining and inspecting geosynthetic materials installations in compliance with MANUFACTURER's standards and with Quality Assurance requirements of this Specification Part 1.2.

2.7 Conformance Testing



- A. Samples of the geomembrane will be removed by the CQA or MANUFACTURER's QC Officer at the MANUFACTURER's plant during production of the geomembrane. Samples will be sent to a geosynthetics CQA laboratory for testing to assure conformance with the requirements of this section. If mutually agreed upon by OWNER, ENGINEER, CONTRACTOR, and FDEP, samples may be shipped from MANUFACTURER to the CQA Officer's designated laboratory, provided that adequate chain-of-custody documentation is prepared and submitted, including origin and destination of sample, lot number, roll number, product name, project name, date of production, and date of shipment, at a minimum.
- B. Samples and tests will be selected by the CQA or MANUFACTURER's QC Officer in accordance with this section and with the procedures outlined in the CQA Plan.
- C. Samples will be taken at a minimum frequency of one sample per 100,000 square feet with a minimum of one sample per lot. If the MANUFACTURER ships geomembrane that requires sampling and testing at a frequency greater than one per 90,000 square feet, then the MANUFACTURER shall pay for the cost of the additional CQA sampling and testing beyond one sample per 90,000 square feet.
- D. The CQA Officer may increase the frequency of sampling in the event that test results do not comply with the requirements of Parts 2.2 and 2.3 of this section. CONTRACTOR shall bear the expense of this additional testing.
- E. At a minimum, the geomembrane tests will include those identified in Section 2.3B.
- F. Any geomembranes that are not certified in accordance with Part 1.3 of this section, or that do not comply with Parts 2.2, 2.3 and 2.4 of this section, will be rejected by ENGINEER. CONTRACTOR shall replace the rejected material with new material, at no additional cost to OWNER.

PART 3 - Execution

3.1 Geosynthetic Liner System

A. Subbase:

- 1. Protect GCL and subbase at all times from damage until such time as the placement of HDPE geomembrane liner and other components of the geosynthetic liner system are complete.
- 2. The subbase shall be prepared in a manner consistent with proper subbase preparation techniques for the installation of HDPE Geomembrane.
 - a. The subbase shall be properly compacted so as not to settle and cause excessive strains in the HDPE Geomembrane or other synthetic liner materials.
 - b. Prior to installation, ensure a surface free of debris, roots, or angular stones larger than 1/2 inch.
 - c. In addition, ensure that the subbase has been rolled to provide a uniform surface.
 - d. During installation, ensure that rutting or ravelling is not caused by installation equipment or weathering.
 - e. Do not drag geomembrane above GCL. Damages to the GCL caused by the Contractor shall be repaired by the Contractor at the Contractor's expense.

B. Anchor Trenches:

- 1. Geosynthetic materials placed on side slopes shall be anchored into trenches as detailed on the Contract Drawings.

2. Excavation, backfill and compaction shall be in accordance with Section 02300.

C. HDPE Geomembrane:

1. Do not deploy geomembrane until all inspections of the GCL layer are complete and approval has been given by the Engineer. The Engineer and Owner shall be notified a week in advance of initial deployment of geomembrane.
2. General:
 - a. INSTALLER of HDPE geomembranes is responsible for handling, fitting, welding, seaming, jointing and testing of geosynthetic materials sheets or blankets in the field in accordance with the Construction Quality Assurance (CQA) Plan.
 - b. These responsibilities include but are not limited to:
 - 1) Acceptance (in writing) of the geosynthetic materials sheets or blankets from the transporter.
 - 2) Acceptance (in writing) of the subbase soil layer which will serve as a base for the HDPE geomembrane.
 - a) This acceptance shall precede installation of the HDPE geomembrane.
 - b) Shall state that the INSTALLER has inspected the surface, and reviewed the Specifications for material and placement, and finds all conditions acceptable for placement of HDPE geomembrane liners.
 - c) Shall explicitly state any and all exceptions to acceptance.
 - 3) Handling, welding, seaming, jointing, testing and repair of HDPE geomembrane liners and other geosynthetic materials in compliance with this Specification and with written procedures manuals prepared by the MANUFACTURER.
 - a) Manual shall be submitted to the ENGINEER together with Shop Drawings showing the layout of HDPE geomembrane within the facility.
 - (1) Do not deviate from the procedures included in the manual.
 - b) HDPE Geomembrane shall not be placed upon frozen foundation, standing water or other conditions which will result in deterioration of the foundation.
 - c) HDPE Geomembrane liner materials shall be laid out according to plans previously approved by the ENGINEER.
 - d) Adjacent rolls of HDPE geomembrane shall overlap a minimum of 3 inches, provided that greater overlap may be required to allow seaming in accordance with the MANUFACTURER's instructions.
 - 4) Repair or replacement of defects in the geosynthetic materials as required by the Inspector or the OWNER.
 - 5) INSTALLER and MANUFACTURER may be the same firm.
 - c. Panel deployment:
 - a. Only those panel/sheets that can be seamed in 1 day shall be deployed.
 - b. Place panels with minimal handling.
 - 1) Orient sheets to eliminate or minimize number of horizontal seams on side slopes.
 - 2) Protect panels from tear, puncture or abrasion.
 - 3) No seams will be permitted in the leachate collection trench.
 - c. Equipment used to deploy the geomembrane shall not damage or rut the subbase layer.
 - 1) A rut is defined as a 1/4 inch depression over a 10 feet straight-edged length.

- d. No vehicular traffic is permitted on unprotected HDPE geomembrane, except for low-ground pressure equipment necessary for deployment and installation of overlaying geosynthetic layers.
- e. Minimize foot traffic.
 - 1) Do not allow personnel access to wet or slippery liners without adequate safety precautions.
 - 2) Do not allow footwear that may damage the geomembrane.
- f. Ballast with sandbags to prevent wind uplift as recommended by MANUFACTURER based on local climatic conditions.
 - 1) Remove and replace all wind damaged panels at no additional cost to OWNER.
 - 2) If wind causes panels to be displaced, displaced panel may not be reused.
- g. Install HDPE geomembrane in stress free, tension free and relaxed condition.
 - 1) Account for temperature and weather-related impacts when deploying and covering.
 - 2) Stretching to fit and folding are not permitted.
- h. Do not allow HDPE geomembrane to bubble, fold, or create ripples as a result of deployment of drainage layer or protective soil cover placement.
 - 1) Except as noted on Contract Drawings no folds in HDPE geomembrane will be allowed.
- i. Any panel exhibiting stretching caused by placement, covering techniques, or wind shall be removed and may not be incorporated in the final construction.
- j. Field seaming:
 - 1) Field seaming shall be done in accordance with seaming recommendations furnished by the geomembrane MANUFACTURER and referenced EPA documents.
 - 2) Each piece of seaming equipment and each operator shall perform demonstration seams at the start of a shift, whenever equipment is switched on or seaming is interrupted for more than ten minutes, and at other times at the discretion of the INSTALLER and Inspector.
 - 3) Demonstration seams shall use the same seaming materials and methods to be used in the actual construction.
 - 4) Surfaces to be seamed shall be clean and dry at the time of seaming.
 - a) Precipitation and ponding of water on the HDPE geomembrane shall cause termination of seaming operations.
 - b) HDPE geomembrane shall not be seamed when ambient temperatures are below 41 DegF or above 104 DegF, without written consent of HDPE geomembrane MANUFACTURER and ENGINEER.
 - 5) HDPE geomembrane sheets shall be seamed continuously without fishmouths or breaks in the seam.
 - a) Where fishmouths are unavoidable, the sheet shall be slit to a point such that the sheet lies flat and with no remaining wrinkle.
 - b) The two edges of the slit shall be seamed together provided that the overlap for this seam shall be a minimum of 6 inch.
 - c) Areas of the slit which do not achieve an overlap of 6 inch, including the terminus of the slit, shall be provided with a patch as discussed below.
 - 6) All HDPE geomembranes shall be seamed by thermal fusion methods as recommended by the HDPE geomembrane MANUFACTURER.
 - a) HDPE geomembrane seaming shall be double wedge weld unless otherwise approved or prohibited by construction.

- 7) MANUFACTURER's seaming instructions shall specifically address subgrade preparation, seaming materials, temporary and permanent jointing, seaming temperatures including temperatures for seaming materials, seam finishing and curing.
 - 8) A copy of MANUFACTURER's seaming instructions shall be available on site at all times and shall not be deviated from without written approval of the MANUFACTURER and ENGINEER.
 - 9) All panels/sheets should be overlapped a minimum of 3 inch.
 - a) If horizontal seams are required on side slopes, the upper panel should be lapped over the lower panel.
 - 10) Seaming shall not be conducted in the presence of standing water and/or soft subgrades.
 - a) The seamed area shall be cleaned of dust, dirt and foreign material prior to and during the seaming operation.
 - 11) Seaming shall extend to the outside edge of panels/sheets to be placed in anchor and/or drainage trenches.
 - 12) Tack welds shall conform with manufacturers seaming techniques and shall not damage underlying membrane.
- k. Patching:
- 1) Defects in and damage to HDPE geomembrane sheets shall be repaired by seaming a patch over the defect.
 - a) The patch material shall consist of an undamaged piece of HDPE geomembrane cut to provide a minimum of 6 inch of overlap in all directions from the defect.
 - b) Round corners shall be utilized on all patches. No bead or spot patching will be accepted.
 - c) Torn or permanently twisted HDPE geomembrane shall be replaced at no expense to the OWNER.
 - 2) Test all patch seams using one of the following nondestructive tests: vacuum tests; spark tests; or ultrasonic tests.
 - a) Test patch seams destructively at a frequency of ten percent or a minimum of one test per seaming personnel per day.
 - b) This destructive testing may be accomplished using demonstration seams performed adjacent to the liner installation.
- l. Smoking is not permitted while on the geomembrane.
- m. Field Panel Identification: The INSTALLER's QC Consultant will document that the Geomembrane INSTALLER labels each field panel with an "identification code" consistent with the approved panel layout plan. The location of the label and the color of marker used must be as agreed to in the QA/QC Preconstruction Meeting.

3.2 Field Quality Control

- A. Inspector shall not be a part of the installation program and shall not serve as a substitute for performing the duties or certification required of the MANUFACTURER and INSTALLER.
1. Inspector's responsibilities include, but are not limited to:
 - a. Inspection of the material and the handling and field installation of the geomembranes. Inspection of all welds, repairs and quality control test results.



- b. All exceptions to material or installation shall be documented and furnished to the CQA Officer in writing within 48 hours of discovery.
 - c. Inspection and Certification of HDPE geomembrane integrity until completion of placement of protective soil cover.
- B. Trial Seam Testing:
- 1. Trial seams shall be made each half-day prior to production seaming.
 - a. The location of trial seam shall be in an area proposed for the day's production seaming.
 - b. Equipment, methods and personnel shall be the same as proposed for the day's seaming.
 - 2. Test five replicates (1 inch wide specimens) cut from trial seam. Field seaming cannot begin until successful trial seams have been completed.
 - a. To be acceptable, five of five replicate test specimens must meet specified seam strength requirements. The break must occur in the liner material itself, not through peel separation (FTB).
 - b. If the field tests fail to meet these requirements, the entire operation shall be repeated.
 - c. If the additional test seams fail, the seaming apparatus or seamer shall not be accepted or used for seaming until the deficiencies are corrected and two consecutive successful test seams are achieved.
- C. Non-Destructive Seam Testing:
- 1. All field seams shall be non-destructively tested over their full length.
 - a. Seam testing shall be performed as the seaming work progresses, not at the completion of field seaming.
 - b. All testing shall be documented. Any seams which fail shall be repaired and documented.
 - 2. Non-destructively test all field seams continuously using one of the following nondestructive seam tests: vacuum box; and pressurized air channel test.

Vacuum Testing:

- a. The equipment shall comprise the following.
 - i. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.
 - ii. A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections.
 - iii. A rubber pressure/vacuum hose with fittings and connections.
 - iv. A bucket and applicator.
 - v. A soapy solution.
- b. The following procedures shall be followed.
 - i. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi gauge.
 - ii. Wet a strip of geomembrane seam having an area larger than the vacuum box assembly 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 10 seconds.
 - vii. If no bubbles appear after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3-in. 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 repaired in accordance with Paragraph 3.3 of this section.
3. Air Pressure Testing (For Double Fusion Seams Only):
- a. The following procedures are applicable to those processes that produce a double seam with an enclosed space.
 - b. The equipment shall comprise the following.
 - i. An air pump (manual or motor driven), equipped with a pressure gauge, capable of generating and sustaining a pressure between 25 and 30 psi, mounted on a cushion to protect the geomembrane.
 - ii. A rubber hose with fittings and connections.
 - iii. A sharp 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 channel 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, close valve, allow two minutes for pressure to stabilize, and sustain the pressure for not less than 5 minutes.
 - v. If loss of pressure exceeds 4 psi, or if the pressure does not stabilize, locate faulty area and repair in accordance with Paragraph 3.3 of this section.
 - vi. Cut opposite end to verify continuity of seam, remove needle, or other approved pressure feed device, and seal repair in accordance with Paragraph 3.3 of this section.
- D. Destructive Seam Testing:
- 1. A minimum of one destructive test per 500 linear feet of seam, and as many other samples as CQA Officer determines appropriate, shall be obtained at locations specified by the CQA Officer. Minimum frequency shall be extended up to 1000 feet if electrical leak location survey method is used.
 - a. Sample locations shall not be identified prior to seaming.
 - b. The samples shall be a minimum of 12 inch wide by 48 inch long with the seam centered lengthwise. Sample size will be adjusted for double track seams or dual hot wedge seams to include both sets of seams.
 - c. Each sample shall be cut into three equal pieces with one piece retained by the INSTALLER, one piece given to a CQA Testing Laboratory, and the remaining piece given to the CQA Officer for quality assurance testing and/or permanent record.
 - d. Each sample shall be numbered and recorded on the final panel layout record drawing, and cross-referenced to a field log which identifies:



- 1) Panel/sheet number.
- 2) Seam number.
- 3) Top sheet.
- 4) Date and time cut.
- 5) Ambient temperature.
- 6) Seaming unit designation.
- 7) Name of seamer.
- 8) Seaming apparatus temperature and pressures (where applicable).
2. A minimum of four 1 inch wide replicate specimens shall be cut from the INSTALLER's sample.
 - a. A minimum of 2 specimens shall be tested for shear strength and 2 for peel adhesion using an approved field quantitative tensiometer. Jaw separation speed shall be 2 inch per minute.
 - b. To be acceptable, all replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.
 - c. If the field tests pass, 5 specimens shall be tested at the CQA Testing Laboratory for shear strength and 5 for peel adhesion in accordance with ASTM D4437.
 - d. To be acceptable, 4 out of 5 replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond and the fifth sample meets 80% of the required strength.

3. The minimum required seam strengths are:

<u>Description</u>	<u>Test Method</u>	<u>Required Value (lbs/in width)</u>
HDPE Peel (Hot Wedge)	ASTM D4437	91
HDPE Shear (all)	ASTM D4437	120
HDPE Peel (Extrusion)	ASTM D4437	78

4. If the field tests pass, 5 specimens shall be tested at the CQA Testing Laboratory for shear strength and 5 for peel adhesion in accordance with ASTM D4437.
 - a. To be acceptable, 4 out of 5 replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.
 - b. If the field or laboratory tests fail, the seam shall be repaired in accordance with the MANUFACTURER's Quality Control manual.
 - c. In addition, all destructive seam sample holes shall be repaired the same day as cut.
 - d. Certified test results on all field seams shall be submitted to and approved by the CQA Officer prior to acceptance of the seam.
5. Repaired areas shall be destructively tested at a minimum of every 500 linear feet of extrusion weld. Minimum frequency shall be extended up to 1000 feet if electrical leak location survey method is used.
 - a. All repaired areas shall be non-destructively tested.
6. Destructive testing shall be performed by a CQA Testing Laboratory not employed by the INSTALLER.

7. A map showing the locations, number and type of all patches shall be prepared and provided to the OWNER.
 8. Documentation: The following documentation must be maintained at the project site for review by the CQA Officer, ENGINEER, or Inspector.
 - a. Geomembrane INSTALLER's Documentation:
 - 1) Daily Log: daily record that summarizes panels deployed, seams completed, seam testing, seam repair, personnel on site, weather conditions, and equipment on site.
 - 2) Material Conformance: maintain original conformance certificate(s) from geomembrane manufacturer.
 - 3) Subgrade Acceptance Log: maintained originals of subgrade acceptance forms for each panel and signed by the Geomembrane INSTALLER.
 - 4) Panel Log: provides geomembrane roll number used and subgrade acceptance for each panel deployed.
 - 5) Seam Testing Log: provides a complete record of all nondestructive and destructive seam tests performed as part of the Geomembrane INSTALLER's QC program.
 - 6) Seam/Panel Repair Log: provides a complete record of all repairs and vacuum box testing of repairs made to defective seams or panels.
 - 7) As-Built Drawing: maintain an as-built drawing updated on a weekly basis.
- E. Destructive Test Failure:
- 1) The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the CQA laboratory, the Geosynthetics Installer's laboratory, or by a field tensiometer. The Geosynthetics Installer shall have two options, as described in b and c below.
 - 2) The Geosynthetics Installer can reconstruct the seam (e.g., remove the old seam and reseat) between any two passed test locations.
 - 3) The Geosynthetics Installer can trace the welding path to an intermediate location, a minimum of 10 ft 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. 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 where the length of reconstructed seam exceeds 150 ft, a destructive sample taken from within the reconstructed zone must pass destructive testing. Whenever a sample fails, the CQA Officer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.
 - 4) CONTRACTOR shall bear the cost of the destructive testing by the CQA laboratory for those seam samples associated with b. and c. above.

3.3 Defects And Repairs

1. All seams and non-seam areas of the geomembrane will be examined by the CQA Officer 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 examination. The geomembrane surface shall be swept or washed by the Geosynthetics INSTALLER if surface contamination inhibits examination. The Geosynthetics INSTALLER shall ensure that this examination 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 Paragraph 3.2 of this section, as appropriate. Each location that fails nondestructive testing shall be marked by the CQA Officer and repaired by the Geosynthetics INSTALLER. Work shall not proceed with any materials that will cover repaired locations until laboratory test results with passing values are available.
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 Officer shall identify excessive geomembrane wrinkles. The Geosynthetics INSTALLER shall cut and reseat 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 Geosynthetics INSTALLER. Several repair procedures are specified below. The final decision as to the appropriate repair procedure shall be agreed upon between the CQA Officer and the Geosynthetics INSTALLER. The procedures available include:
 - i. patching - used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
 - ii. abrading and reseaming - used to repair small sections of extruded seams;
 - iii. spot seaming - used to repair small tears, pinholes, or other minor, localized flaws;
 - iv. capping - used to repair long lengths of failed seams; and
 - v. 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 that are to be repaired shall be abraded no more than one hour 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 by ENGINEER;
 - iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the CQA Officer and Geosynthetics INSTALLER;



- v. patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 inches.; and
 - vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.
5. Each repair shall be numbered and logged and shall be nondestructively tested using the methods described in Paragraph 3.2 of this section, as appropriate. Repairs that 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 result is achieved. At the discretion of the CQA Officer, destructive testing may be required on large caps at no additional cost to OWNER.
6. The Geosynthetics INSTALLER shall repair damage to the existing HDPE liner the Area 3/Area 4 tie-in location. Repairs shall be made according to this Specification.

3.4 Material In Contact With Geomembrane

- A. The Geosynthetics INSTALLER 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 liner system or by other construction activities. If approved by the CQA Officer, additional loosely placed geotextile sections may be used by the Geosynthetics INSTALLER to protect the geomembrane.
- B. No granular materials shall be placed directly on the geomembranes at any time. A nonwoven geotextile or geocomposite shall be installed between aggregate and geomembrane and between geonet edges and geomembrane.
- C. Unless otherwise specified by ENGINEER, all equipment operating on earthen materials overlying geosynthetics shall comply with the following:

<u>Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Overlying Compacted Soil (ft)</u>
<5	1.0
<10	1.5
<20	2.0
>20	3.0

- D. In heavily trafficked areas such as access ramps, and in areas trafficked by rubber tire vehicles, the thickness of overlying compacted fill shall be at least 3 ft.
- E. Connection of the geomembrane to appurtenances shall be made according to these Specifications and as shown on the Drawings. Extreme care shall be taken while seaming around appurtenances since neither nondestructive nor destructive testing may be feasible in these areas. The Geosynthetics INSTALLER shall ensure that the geomembrane has not been damaged while making connections to appurtenances.

3.5 Geosynthetic Liner System Acceptance

- A. CONTRACTOR shall retain all ownership and responsibility for the geosynthetic bottom liner system until final acceptance by the OWNER.
 - 1. OWNER will accept the geosynthetic liner system installation when the installation is finished and all required warranties, test results, and documentation from the CONTRACTOR, MANUFACTURER, Inspector and INSTALLER has been received and approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

END OF SECTION

Section 02776

Geosynthetic Clay Liner (GCL)

PART 1 - General

1.1 Summary

- A. Section Includes:
 - 1. Purchasing, delivery, installation, quality control, and testing of a GCL for a landfill bottom liner system.
- B. Related Sections include but are not necessarily limited to:
 - 1. Section 02300 – Earthwork for Liner Construction
 - 2. Section 02775 – HDPE Geomembrane Liner

1.2 Quality Assurance

- A. Referenced Standards:
 - 1. ASTM International (ASTM):
 - a. D2216, Moisture Content of Soil.
 - b. D4632, Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).
 - c. D4643, Determination of Water Content of Soil by Microwave Owen Method.
 - d. D4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
 - e. D4873, Identification, Storage and Handling of Geosynthetic Rolls.
 - f. D5261, Measuring Mass Per Unit Area of Geotextiles.
 - g. D5321, Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
 - h. D5887, Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeater.
 - i. D5888, Guide for Storage and Handling of Geosynthetic Clay Liners.
 - j. D5889, Quality Control of GCL.
 - k. D5890, Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
 - l. D5891, Fluid Loss of Clay Component of Geosynthetic Clay Liners.
 - m. D5993, Test Method for Measuring Mass Per Unit Area of Geosynthetic Clay Liners.
 - n. D6072, Obtaining Samples of GCL
 - o. D6102, Guide for Installation of Geosynthetic Clay Liners.
 - p. D6243, Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
 - q. D6496, Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle Punched GCLs.
 - r. D6766, Evaluation of Hydraulic Properties of GCLs permeated with Potentially Incompatible Liquids.
 - s. D6768, Tensile Strength of Geosynthetic Clay Liner.
 - 2. Geosynthetic Research Institute (GRI):
 - a. GCL-3, Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs).

- B. Quality Assurance:
 - 1. The CQA Inspector will direct testing to support construction quality assurance program and to provide documentation of such to appropriate regulatory agencies.
 - 2. The CQA Inspector will observe that the GCL is stored, placed, seamed, and protected as described in ASTM D4873, D5888 and D6102.
- C. Qualifications:
 - 1. Each manufacturing firm shall demonstrate 5 years continuous experience, including a minimum of 5,000,000 SF of manufacture/fabrication in geosynthetic lining systems. Aggregate experience shall not apply.
 - 2. Installer shall attend pre-installation conference.

1.3 Definitions

- A. Manufacturer: Manufacturer produces geosynthetic clay liner panels from first quality geotextiles and sodium bentonite. The manufacturer is responsible for producing panels which comply with this Specification.
- B. Installer: Installers of GCLs are responsible for storing, handling, fitting, seaming and testing of GCL panels in the field. Installer and manufacturer may be the same firm.
- C. Hydrated GCL is defined as material which has become soft as determined by squeezing the material with finger pressure, material which has exhibited swelling, or material which has a moisture content greater than 100 percent as determined by ASTM D2216.

1.4 Submittals

- A. Shop Drawings:
 - 1. Manufacturer's documentation that bentonite, geotextiles and GCL comply with required material properties.
 - 2. Manufacturer and Installer quality control manuals.
- B. Miscellaneous Submittals:
 - 1. Test results:
 - a. Bentonite, geotextile and GCL tests at frequency specified in respective quality control manuals. Results shall include or bracket the rolls delivered for use in the Work.
 - 2. Qualification documentation specified in Article 1.2.
 - 3. Submit written certifications that:
 - a. The GCL delivered to site meets the requirements of this Specification.
 - b. The GCL was received and accepted in undamaged condition from shipper.
 - c. The subbase has been properly prepared and acceptable for the placement of the GCL.
 - d. The GCL was installed in accordance with this Specification and with approved shop drawings.
 - e. The geomembrane on top of the GCL was placed properly and carefully.

1.5 Delivery, Storage and Handling

- A. Do not place GCL rolls directly on the ground.
- B. Store and protect GCL from dirt, water, ultraviolet light and other sources of damage.
- C. Label, handle, and store GCL in accordance with ASTM D4873 and as specified herein.

1. Wrap each roll in an opaque and waterproof layer of plastic during shipment and storage.
2. Do not remove the plastic wrapping until deployment.
- D. Label each roll with the manufacturers name, lot number, roll number, and roll dimensions (length, width, gross weight).
 1. Repair or replace GCL or plastic wrapping damaged as a result of storage or handling, as directed.
 2. Do not expose GCL to temperatures in excess of 71 DegC (160 DegF) or less than 0 DegC (32 DegF) unless recommended by the Manufacturer.
- E. Do not use hooks, tongs or other sharp instruments for handling the GCL. Do not lift rolls by use of cables or chains in contact with the GCL. Do not drag GCL along the ground.
- F. Damaged rolls may be rejected. If rejected, it must be verified that rejected material is removed from the site or stored at a location separate from accepted rolls. GCL rolls that do not have proper manufacturer's documentation must be stored at a separate location until all documentation has been received and approved.

1.6 Warranty

- A. The Manufacturer shall provide a 5-year warranty to the Owner against manufacturing defects. The warranty shall include defective product found to be not in compliance with the requirements of this specification. Warranty shall not be prorated.

PART 2 - Products

2.1 Acceptable Manufacturers

- A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 1. Geosynthetic Clay Liners:
 - a. CETCO, 1500 W. Shore Drive, Arlington Heights, Illinois 60004.
 - b. GSE/Bentofix Technologies Inc., 23 Truman Road, Barrie, Ontario L4M 3V7

2.2 Materials

- A. Geosynthetic Clay Liner:
 1. The active ingredient of the GCL shall be natural sodium bentonite. Encapsulate bentonite between two geotextiles.
 2. Lock-stitch or heat-seal needle punched geotextile backed GCL with high strength polypropylene thread to provide internal shear strength reinforcing. The internal shear reinforcing mechanism shall resist failure due to thread pull-out over long-term creep situations.
 3. Continuously adhere the bentonite to both geotextiles to ensure that the bentonite will not be displaced during handling, transportation, storage and installation, including cutting, patching and fitting around penetrations. The bentonite sealing compound or bentonite granules used to seal penetrations and make repairs shall be made of the same natural sodium bentonite as the GCL and shall be as recommended by the GCL manufacturer. The permeability of the GCL overlap seams shall be equal to or less than the permeability of the body of the GCL sheet.
 4. Provide material meeting GRI-GCL 3 or as specified in Table 1 below.

Table 1: GCL Properties

Item	ASTM Test Method	Test Value	Min. Test Frequency	
			MQC	CQA
Geotextile Property				
Cap Nonwoven, mass/unit area	ASTM D5261	6 oz/sy	1/200,000 ft ²	1/100,000 ft ²
Carrier Scrim Nonwoven, mass/unit area	ASTM D5261	6 oz/sy	1/200,000 ft ²	1/100,000 ft ²
Bentonite Property				
Minimum Free Swell	ASTM D5890	24 ml/2 g min	1/100,000 lbs	1/100,000 ft ²
Maximum Moisture Content	ASTM D4643 or D2216	12%	1/100,000 ft ²	---
Maximum Fluid Loss	ASTM D5891	18 mL	1/100,000 lbs	---
Finished GCL Property				
Maximum Hydraulic Conductivity (MARV)	ASTM D5887 @5 psi max. confining stress	5x10 ⁻⁹ cm/s	1/100,000 ft ²	1/100,000 ft ²
Minimum Bentonite Content (MARV)	ASTM D5993 (@ 0% moisture)	0.75 lb/sf	1/40,000 ft ²	1/100,000 ft ²
Typical Internal Shear Strength	ASTM D6243	500 psf (when hydrated)	1/project	---
Minimum peel strength, MD (MARV)	ASTM D6496	5.3 lbs/in	1/40,000 ft ²	---
Tensile strength, MD (MARV)	ASTM D6768	45 ppi	1/40,000 ft ²	---

2.3 Source Quality Control

A. Interface Friction Tests.

1. This material is part of a system. The system shall meet the requirements before the component material can be deemed acceptable. Testing will include the interfaces between the following adjacent materials:
 - Subbase/GCL
 - GCL/60 mil Textured HDPE Geomembrane
 - 60 mil HDPE Geomembrane/Geocomposite
 - Geocomposite/Protective Cover
2. Interface friction angle testing is the responsibility of the COUNTY. All failing tests shall be the CONTRACTOR's responsibility. Requirements are based on standard practice and permit conditions.

B. The testing shall be performed as follows.

1. Conduct one set of three direct-shear interface friction tests on each of the interfaces listed above. Normal stresses of 5,000 psf, 10,000 psf, and 20,000 psf shall be used during hydration and shearing. Samples shall be allowed to hydrate for a minimum of 3 days prior to shear testing. Orient all geosynthetic materials such that the shear force is parallel to the downslope orientation of these components in the field.
2. A minimum friction angle of 23 degrees is required for each interface in the system defined in Paragraph A.
3. Test interface friction between the GCL and adjacent materials in accordance with ASTM D6243, Procedure B.

PART 3 - Execution

3.1 Installation

- A. Construct, inspect and test geosynthetic clay liner in accordance with manufacturer's recommendations, this specification and ASTM D6102.
- B. Halt installation when the weather is of such a nature as to endanger the integrity and quality of the installation.
- C. Assure adequate dust control methods are in effect to prevent the unnecessary accumulation of dust and dirt.
- D. Maintain natural surface water drainage diversions around the work area and provide for the disposal of water which may collect in the work area directly from precipitation falling within the area or from inadequate diversion structures or practices.
- E. Do not allow vehicles in direct contact with the deployed GCL.
- F. Subbase Preparation:
 1. Prepare subbase in a manner consistent with proper subbase preparation techniques for the installation of GCL.
 2. Properly compact the subbase so as not to settle and cause excessive strains in the GCL or other synthetic liner materials.
 3. Prior to installation, ensure a surface free of debris, roots, or angular stones larger than 1/2 IN.
 4. Subbase soils proof-rolled with a ten (10) ton drum roller, two (2) passes in each of two (2) perpendicular directions or as directed by CQA Inspector. The subgrade shall be compacted and proof-rolled under observation of the CQA Inspector to assure the maximum practical compaction under the existing field conditions has been achieved. See specification Section 02220 for project specific compaction requirement.
 5. Ensure rutting or raveling is not caused by installation equipment or weather.
 6. Ensure that lines and grades have been verified by the Contractor and a subgrade acceptance form has been submitted.
- G. Construct and backfill anchor trenches.
- H. Deploy GCL in a manner to ensure it is not damaged.
- I. On slopes, anchor the GCL securely and deploy it down the slope in a controlled manner.
- J. Weight the GCL with sandbags or equivalent in the presence of wind.

- K. Minimize cutting GCL. Whenever possible, overlap instead of cutting material. If cutting is required, cut GCL with a cutter or other approved device. Seal all cut edges, as recommended by Manufacturer, to prevent loss of bentonite. Protect adjacent materials from potential damage due to cutting of GCL.
- L. During GCL deployment, do not entrap in or beneath GCL, stones, trash, or moisture that could damage GCL.
- M. Visually examine entire GCL surface. Ensure no potentially harmful foreign objects, such as needles, are present.
- N. Do not place GCL in the rain or at times of impending rain.
- O. Do not place GCL in areas of ponded water.
- P. Remove and replace GCL which has been hydrated (above 100% per ASTM 4643) prior to being covered.
- Q. In general, only deploy GCL that can be covered during that day.
- R. If applicable, face the GCL's woven carrier geotextile against soil of prepared subgrade.
- S. Overlaps:
 - 1. Reinforced GCL shall be overlapped a minimum of 12 inches along the sides and a minimum of 18 inches on butt seams or as recommended by manufacturer, whichever is greater.
 - 2. For reinforced needle-punched GCLs, add additional granular bentonite to overlapped area at a rate specified by the manufacturer.
- T. Defects and Repairs:
 - 1. Repair all flaws or damaged areas by placing a patch of the same material extending at least 1 FT beyond the flaw or damaged area. For needle-punched GCLs, add granular bentonite to the overlapped edges of the patch at the manufacturer's recommended rate.
 - 2. Ensure that all defects and defect corrective actions (panel rejected, patch installed, etc.) are recorded, and corrective actions are performed in accordance with this specification.
- U. The CQA Inspector shall observe that the equipment used to install geocomposite does not damage it during handling, deployment, or due to leakage of hydrocarbons or other means.
- V. Crews working on the GCL may not smoke, wear shoes that could damage the GCL, or engage in activities that could damage the GCL.

END OF SECTION

Section 02777

Drainage Composite

PART 1 - GENERAL

1.1 Summary

A. Section Includes:

Purchasing, delivery, installation, quality control, and testing of a geocomposite (heat bonded geonet/geotextile) for a landfill bottom liner system.

B. Related sections include but are not necessarily limited to:

1. Section 02300 – Earthwork for Liner Construction
2. Section 02775 – HDPE Geomembrane Liner
3. Section 02778 - Geotextiles.
4. Construction Quality Assurance Plan.

1.2 Quality Assurance

A. Referenced Standards:

1. ASTM International (ASTM):

- a. ASTM D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
- b. ASTM D 1505-98 Standard Test Method for Density of Plastics by the Density-Gradient Technique.
- c. ASTM D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
- d. ASTM D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
- e. ASTM D4491 - Test Method for Water Permeability of Geotextiles by Permittivity.
- f. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
- g. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
- h. 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.
- i. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
- j. ASTM D5035 - Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method).
- k. ASTM D5199 - Standard Test Method for Measuring Nominal Thickness of Geosynthetics.
- l. ASTM D5261 - Standard Test Method for Mass Per Unit Area of Geotextiles.



- m. ASTM D5321 - Standard Test for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
 - n. ASTM D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
 - o. ASTM D6364 - Test Method for Determining the Short-Term Compressive Behavior of Geosynthetics.
 - p. ASTM D7005 - Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.
2. Geosynthetic Research Institute (GRI).
- a. GRI GC8 – Determination of the Allowable Flow Rate of a Drainage Geocomposite.

B. Qualifications:

- 1. INSTALLER shall attend pre-installation conference.

1.3 Definitions

- A. MANUFACTURER: Manufacturer producing drainage composites from geonet cores and geotextiles.
- B. INSTALLER: The Installers are the individuals actually performing the hands-on work in the field.

1.4 Submittals

INSTALLER/MANUFACTURER shall submit to ENGINEER the following documentation on the geocomposite or equal, as indicated below. Approval of the geocomposite will be made by ENGINEER, based on the documentation, at the sole discretion of ENGINEER. The geocomposite manufacturer quality control tests to be performed are outlined in Part 2.4 of this section.

A. As part of the bid a written statement listing:

- 1. A certification, accompanied by test results, that the geocomposite or equal material meets or exceeds the minimum average roll property values listed in Table 02777-1, for leachate collection and detection geocomposites; and
- 2. Production capacity available for this Contract.

B. A least 14 days prior to manufacturing the geonet component of the geocomposite, the following resin quality control data for each batch of resin assigned for use under this Contract shall be submitted. The certificates shall be signed by responsible parties employed by the manufacturer (such as the production manager). The following shall be included:

- 1. Copies of quality control certificates issued by the resin supplier including the production dates of the raw material and origin of the raw materials used to manufacture the geonet for this Contract;



2. Results of resin density and polymer melt index tests conducted by the resin supplier to verify the quality of the resin used to manufacture the geonet rolls assigned to this Contract and the origin of the resin and quality control certificates issued by the resin supplier; and
 3. A written certification stating that no reclaimed polymer is added to the resin during the manufacture of the geonet assigned for this Contract.
- C. At least 14 days prior to manufacture of the geotextile component of the geocomposite, manufacturing quality control certificates for each batch of resin and each shift's production shall be submitted. The certificates shall identify the origin of the resin and the manufacturer of the resin. The certificates shall be signed by responsible parties employed by the manufacturer (such as the production manager). The quality control certificate shall include:
1. roll numbers and identification;
 2. sampling procedures; and
 3. results of quality control tests, including a description of the test methods used.
- D. Prior to shipment of the geocomposite, manufacturer's quality control certificates for each shift's production of geotextile, geonet, and geocomposite, signed by a responsible party employed by the manufacturer (such as the production manager) shall be submitted. The quality control certificate shall include roll numbers of the material manufactured.
- E. Prior to shipment of the geocomposite, documentation shall be submitted that the geocomposite furnished meets the property values listed in Table 02777-1, for leachate collection and leak detection geocomposites, that will:
1. Retain their structure during handling, placement, and long-term service; and
 2. Be capable of withstanding direct exposure to sunlight for a minimum of 30 days with no measurable deterioration.
- F. At least 14 days prior to shipment of the geocomposite, recommendations for unloading, field handling, and stockpiling of the geocomposite shall be submitted.
- G. At least 14 days prior to shipment of the geocomposite, leachate compatibility test data shall be submitted to ENGINEER.
- H. At least 14 days prior to shipping geocomposite, INSTALLER shall provide the following information to ENGINEER in writing, regarding the Geosynthetic INSTALLER:
1. Corporate background, qualifications and other information contained herein; and
 2. Copy of installer's letter of approval or license by geocomposite manufacturer allowing the installer to install the geocomposite.

- I. Friction angles of selected interfaces of liner for selected geosynthetics and site specific soil shall be submitted as specified in Part 2.3 at least 14 days prior to shipment of geosynthetics. The friction angles shall be above the minimum angles specified.

1.5 Delivery

- A. Label, handle, and store drainage composites in accordance with ASTM D4873 and as specified herein.
- B. Wrap each roll in an opaque and waterproof layer of plastic during shipment and storage. Do not remove the plastic wrapping until deployment.
- C. Label each roll with the manufacturer's name, drainage composite type, lot number, roll number, and roll dimensions (length, width, gross weight).
- D. Repair or replace, as directed by the ENGINEER, drainage composite or plastic wrapping damaged as a result of storage or handling.
- E. Do not expose drainage composite to temperatures in excess of 71 DegC (160 DegF) or below 0 DegC (32 DegF) unless recommended by the MANUFACTURER.
- F. Do not use hooks, tongs or other sharp instruments for handling the drainage composite.
- G. Do not lift rolls by use of cables or chains in contact with the drainage composite.
- H. Do not drag drainage composite along the ground or across textured geomembranes.

PART 2 - PRODUCTS

2.1 Acceptable Manufacturers

- A. The recommended product for the project is 300 mil PermaNet UL Geocomposite as manufactured by GSE Environmental, LLC. If an equivalent product is proposed, then the product information should be submitted with the bid per Part 2.2 D.

2.2 Materials and Manufacturer

A. Geonet Core:

1. The geonet core should be a standard product of the manufacturer. Specifically manufactured cores that meet project specifications are not acceptable.
2. Use non-thermally degraded polyethylene polymer which is clean and free of any foreign contaminants.
3. Manufactured geonet to conform to the property requirements listed in Table 02777-1, and be free of defects including tears, nodules or other manufacturing defects which may affect its serviceability.

B. Geotextile:

1. Cover geonet core on both sides with a geotextile complying with requirements specified in Table 02777-1.

C. Drainage Composite:

1. Create a composite by heat bonding geotextiles to the geonet. Minimum requirements for geocomposite are specified in Table 02777-1, for leachate collection and leak detection geocomposites.

D. Equivalent Material:

1. CONTRACTOR may submit a substitution request for equivalent material that meets the minimum requirements as specified in Table 02777-1. Following should be considered when estimating the equivalency:
2. Minimum thickness 300 mil +/-15%.
3. Compression strength 45,000 psf (ASTM D6364)
4. Minimum transmissivity based on Table 02777-1.
5. 10,000 hr Creep Reduction Factor for geonet core at 10,000 PSF and 40°C shall be less than 1.10.

2.3 Source Quality Control

A. Transmissivity Testing:

1. Measure transmissivity according to ASTM D 4716 as described in Table 02777-1.
2. Attach geotextiles to the geonet in the same configuration as will be used in the field.
3. Boundary conditions for geocomposite are protective cover (or Ottawa Sand) interface on the upper geotextile and 60 mil HDPE geomembrane against the lower geotextile.

4. The testing shall be conducted at 10,000 psf loading for a minimum period of 100 hour.

B. Interface Friction Tests.

1. Refer to Section 02776-Geosynthetic Clay Layer (GCL) for test requirements.

2.4 Manufacturing Quality Control

- A. The geocomposite and its components shall be manufactured with quality control procedures that meet generally accepted industry standards.
- B. The geocomposite MANUFACTURER shall sample and test the geocomposite, and its components, to demonstrate that the material complies with this Specification. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required.
- C. The geocomposite MANUFACTURER shall sample and test the geocomposites, at the specified frequency, to demonstrate that its properties confirm to the values specified in Table 02777-1 for leachate collection and leak detection zones.

The geocomposite MANUFACTURER shall provide test results to ENGINEER demonstrating that the geocomposite MANUFACTURER performed the tests and that results were obtained that meet or exceed the transmissivity value required in Table 02777-1, for leachate collection and leak detection zones.

- D. Any geocomposite sample that does not comply with the Specifications will result in rejection of the roll from which the sample was obtained. MANUFACTURER shall replace any rejected rolls at no additional cost to OWNER.
- E. If a geocomposite sample fails to meet the quality control requirements of this section, the geocomposite MANUFACTURER shall sample and test each roll manufactured in the same lot, 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.
- F. Additional sample testing may be performed, at the geocomposite MANUFACTURER's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.

2.5 CONFORMANCE TESTING

Samples of the geocomposite will be removed by the CQA Consultant or CQA Laboratory Representative at MANUFACTURER's plant during production of the geocomposite. The CQA Consultant or CQA Laboratory Representative will sample the geotextile and geonet components before the components are bonded together and will sample the geocomposite material after the individual components are bonded. Samples will be sent to a geosynthetics CQA laboratory for testing to assure conformance with the requirements of this section. If mutually agreed upon by OWNER, ENGINEER, CONTRACTOR, and FDEP, samples may be shipped from MANUFACTURER to the CQA Officer's designated laboratory, provided that adequate chain-of-custody documentation is prepared and submitted, including origin and destination of sample, lot number, roll number, product name, project name, date of production, and date of shipment, at a minimum.

- B. Samples and tests shall be selected by the CQA Officer in accordance with the procedures outlined in the CQA Plan.
- C. Samples shall be taken at a minimum frequency of one sample per 100,000 square feet with a minimum of one sample per lot. If CONTRACTOR ships geocomposite that requires sampling and testing at a frequency greater than one per 90,000 square feet, then CONTRACTOR shall pay for the additional CQA sampling and testing beyond one per 90,000 square feet.
- D. The CQA Officer may increase the frequency of sampling in the event that test results do not comply with the requirements of this section. CONTRACTOR shall bear the expense of this additional testing.
- E. As a minimum, tests listed in Table 02777-1 shall be performed.
- F. Any geocomposite material that is not certified in accordance with Part 1.4 of this section, or that conformance testing indicates do not comply with Part 2 of this section, will be rejected by ENGINEER. CONTRACTOR shall replace the rejected material with new material, at no additional cost to OWNER

PART 3 - EXECUTION

3.1 Examination

- A. Prior to placement of the drainage composite, clean the surface of all soil, rock, and other materials which could damage the composite.
- B. The geocomposite drainage media shall be placed only on geomembrane that has been approved by the Geomembrane INSTALLER and accepted by the CQA Consultant.

3.2 Installation

- A. Install geocomposite drain in accordance with manufacturer's written recommendations.



- B. Deploy the drainage composite ensuring that the drainage composite and underlying materials are not damaged. Replace or repair faulty or damaged drainage composite as directed by ENGINEER.
- C. Unroll drainage composite downslope keeping in slight tension to minimize wrinkles and folds.
- D. Maintain free of dirt, mud, or any other foreign materials at all times during construction. Clean or replace rolls which are contaminated.
- E. Place adequate ballast to prevent uplift by wind.
- F. Overlap adjacent rolls a minimum of 6 inches. Overlap new drainage composite over existing as shown on the drawings.
- G. Use manufacturer's fasteners to join adjacent rolls. Metallic fasteners will not be allowed. Space fasteners a maximum of 5 feet along downslope roll overlaps and a maximum of 1 foot along cross slope roll overlaps. Use fasteners of contrasting color from the drainage composite to facilitate visual inspection. Do not weld drainage composite to geomembranes.
- H. Heat tack overlap of the upper geotextile to the upper geotextile of the adjacent rolls.
- I. Any holes or tears in the geocomposite material shall be repaired by placing a patch extending 1 foot beyond the edges of the hole or tear. The patch shall be secured by tying fasteners through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet on the slope. The patch shall be secured every 6 inches with approved tying devices. The top geotextile component of the patch shall be thermally bonded to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the entire damaged geocomposite panel shall be removed and replaced.
- J. Penetration details shall be as recommended by the MANUFACTURER and as approved by the ENGINEER.

TABLE 02777-1 DOUBLE SIDED GECOMPOSITE PROPERTY VALUES FOR LEACHATE COLLECTION AND LEAK DETECTION ZONE⁽¹⁾

Properties	Qualifiers	Units	Values	Test Method	Test Frequency	
					MQC	CQA
Geonet Component						
Resin Polymer Melt Index	maximum	g/10 min.	1.0	ASTM D1238	1 per batch	n/a
Polymer Density (geonet)	Minimum	g/cc	0.94	ASTM D 1505	1/100,000 SF	1/100,000 SF
Carbon Black Content	range	%	2.0 - 3.0	ASTM D 1603	1/100,000 SF	1/100,000 SF
Thickness	minimum	mils	300 +/-15%	ASTM D 5199	1/100,000 SF	1/100,000 SF
Tensile Strength (MD and TD)	minimum	lb/in	100	ASTM D 5035	1/100,000 SF	1/100,000 SF
Geotextile Component						
Polymer Composition	minimum	%	95 polyester or polypropylene	-	n/a	n/a
Mass Per Unit Area	minimum	oz/yd ²	6	ASTM D 3776	1/100,000 SF	1/100,000 SF
Apparent Opening Size	maximum	US Sieve	#70	ASTM D 4751	1/100,000 SF	1/100,000 SF
Flow Rate ⁽⁵⁾	minimum	gal/min./ft ²	110	ASTM D 4491	1/500,000 SF	n/a
Permittivity ⁽⁵⁾	minimum	sec ⁻¹	1.2	ASTM D 4491		1/100,000 SF
Grab Strength	minimum	lb	160	ASTM D 4632	1/100,000 SF	1/100,000 SF
CBR Puncture Strength	minimum	lb	435	ASTM D 6241	1/100,000 SF	1/100,000 SF
UV Resistance	minimum	% retained	70	ASTM D 4355 (after 300 hours)	n/a	n/a
Geocomposite						
Transmissivity@10,000 psf ⁽³⁾	minimum	m ² /s	2.0 x 10 ⁻³	ASTM D 4716	1/500,000 SF	1/500,000 SF
Ply Adhesion	minimum	lb/in.	1	ASTM F 904 ⁽⁴⁾	1/100,000 SF	1/100,000 SF

Notes:

- (1) All values represent minimum average roll values (i.e., test results for samples collected from any roll in a lot should meet or exceed these values).
- (2) The density of the net resin shall not exceed that of the geomembrane (see Section 02775).
- (3) Transmissivity @ 100hour: Measure transmissivity using water at 68 DegF with a normal compressive load of 10,000 psf and a hydraulic gradient of 0.02 (ASTM D 4716). Boundary conditions are provided in Section 2.3. Measurements shall be taken 100 hour after application of confining pressure if satisfies the requirements given in Part 2.3A.
- (4) Minimum of values measured in machine and cross machine directions with 1 in. clamp on Constant Rate of Extension (CRE) machine.
- (5) Either flow rate requirement or permittivity requirement shall be met.

END OF SECTION

Section 02778

Geotextiles

PART 1 - General

1.1 Summary

- A. Section Includes:
 - 1. Non-woven geotextile material (except for the geotextile bonded to geocomposite).
 - 2. Woven geotextile material.
- B. Related Sections:
 - 1. Section 02300 – Earthwork for Liner Construction.
 - 2. Construction Quality Assurance Plan.

1.2 Quality Assurance

- A. Referenced Standards:
 - 1. American Association of State Highway Transportation Officials (AASHTO):
 - a. M288, Standard Specification for Geotextile Specification for Highway Application.
 - 2. ASTM International (ASTM):
 - a. D1987, Biological Clogging of Geotextile or Soil/Geotextile Filters.
 - b. D3776, Test Method for Mass Per Unit Area of Woven Fabric.
 - c. D3786, Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method.
 - d. D4354, Sampling of Geosynthetics for Testing.
 - e. D4355, Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
 - f. D4491, Water Permeability of Geotextiles by Permittivity.
 - g. D4533, Trapezoid Tearing Strength of Geotextiles.
 - h. D4595, Tensile Properties of Geotextiles by the Wide-Width Strip Method.
 - i. D4632, Grab Breaking Load and Elongation of Geotextiles.
 - j. D4751, Determining Apparent Opening Size of A Geotextile.
 - k. D4759, Determining the Specification Conformance of Geosynthetics.
 - l. D4833, Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
 - m. D4873, Identification, Storage, and Handling of Geosynthetic Rolls.
 - n. D5261, Test Method for Measuring Mass Per Unit Area of Geotextiles.
 - o. D6193, Standard Practice for Stitches and Seams.
- B. Qualifications:
 - 1. Each manufacturing, fabricating firm shall demonstrate 5 years continuous experience, including a minimum of 10,000,000 SF of geotextile installation in the past 3 years.
 - 2. Installing firm shall demonstrate that the site Superintendent or Foreman has had responsible charge for installation geotextile on several projects of a similar scope.
 - 3. Installer shall attend pre-installation conference.

1.3 Definitions

- A. Manufacturer: Manufacturer producing geotextile sheets from resin and additives.
- B. Installer: The Installers are the individuals actually performing the hands-on work in the field.
- C. MARV: Minimum Average Roll Value

1.4 Submittals

- A. Shop Drawings:
 - 1. Manufacturer's documentation that raw materials and roll materials comply with required geotextile physical properties.
 - 2. Manufacturer and Installer quality control manuals.
 - 3. Original test results for resins, roll material and factory seam tests at frequency specified in respective quality control manuals. Results shall include or bracket the rolls delivered for use in the Work.
 - 4. Proposed details of anchoring and overlapping if different than included in Contract Documents.
- B. Miscellaneous Submittals:
 - 1. Provide same certifications specified in Section 02777. No alterations, additions, deletions, or exception shall be made to the specified language.
 - 2. For needle punched geotextiles, the Manufacturer shall certify that the geotextile has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers.
 - 3. Qualification documentation.

1.5 Delivery, Storage and Handling

- A. Label, handle, and store geotextiles in accordance with ASTM D4873 and as specified herein.
- B. Wrap each roll in an opaque and waterproof layer of plastic during shipment and storage. Do not remove the plastic wrapping until deployment.
- C. Label each roll with the manufacturer's name, geotextile type, lot number, roll number, and roll dimensions (length, width, gross weight).
- D. Repair or replace geotextile or plastic wrapping damaged as a result of storage or handling, as directed.
- E. Do not expose geotextile to temperatures in excess of 71 DegC (160 DegF) or less than 0 DegC (32 DegF) unless recommended by the manufacturer.
- F. Do not use hooks, tongs or other sharp instruments for handling geotextile. Do not lift rolls lifted by use of cables or chains in contact with the geotextile. Do not drag geotextile along the ground.

PART 2 - Products

2.1 Acceptable Manufacturers

- A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. GSE Lining Technology
2. Thrace-LINQ
3. Mirafi (Ten Cate Geosynthetics)
4. Propex
5. SKAPS Industries
6. Tenax Corp

2.2 Materials And Manufacture

A. Geotextile:

1. Non-woven pervious sheet of polymeric material.
2. Geotextile fibers:
 - a. Long-chain synthetic polymer composed of at least 85 percent by weight polyolefins, polyesters, or polyamides.
 - b. Filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure.
 - c. Do not as reclaimed or recycled fibers or polymer to the formulation.
3. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages.
 The geotextile physical properties shall equal or exceed the minimum average roll values listed below. Values shown are for the weaker principal direction.
 Acceptance of geotextile shall be in accordance with ASTM D4759.
 - a. Separation Geotextile (woven, monofilament).

PROPERTY	TEST METHOD	MARV	MIN. MQC TEST FREQUENCY
Ultraviolet Degradation, % retained @ 500 hrs	ASTM D4355	90	1per formulation
Trapezoidal Tear (MD), lbs	ASTM D4533	100	1 per 100,000 ft ²
Trapezoidal Tear (CD), lbs	ASTM D4533	60	1 per 100,000 ft ²
Wide Width Tensile Strength (MD), lbs/in	ASTM D4595	225	1 per 540,000 ft ²
Wide Width Tensile Strength (CD), lbs/in	ASTM D4595	145	1 per 540,000 ft ²
Grab Tensile (MD), lbs	ASTM D4632	370	1 per 100,000 ft ²
Grab Tensile (CD), lbs	ASTM D4632	250	1 per 100,000 ft ²
AOS, U.S. Sieve, mm	ASTM D4751	0.212	1 per 540,000 ft ²
Mullen Burst, psi	ASTM D3786	450	1 per 540,000 ft ²
Permitivity, sec ⁻¹	ASTM D4491	0.280	1 per 540,000 ft ²

B. Thread:

1. High-strength polyester, nylon, or other approved thread type.
2. Equivalent chemical compatibility and ultraviolet light stability as the geotextile.
3. Contrasting color with the geotextile.

2.06 Conformance Testing

- A. Samples of the geotextile shall be removed by the CQA Consultant and sent to a geosynthetics CQA laboratory for testing to assure conformance with the requirements of this section. This testing shall be completed prior to deployment of geotextile. If mutually agreed upon by OWNER, ENGINEER, CONTRACTOR, and FDEP, samples may be shipped from Manufacturer to the CQA Consultant's designated laboratory, provided that adequate chain-of-custody documentation is prepared and submitted, including origin and destination of sample, lot number, roll number, product name, project name, date of production, and date of shipment, at a minimum.
- B. Samples and tests will be selected by the CQA Consultant in accordance with the procedures outlined in the CQA Plan.
- C. Samples shall be taken at a minimum frequency of one sample per 100,000 ft² with a minimum of one sample per lot. If the Geotextile Manufacturer ships geotextile that requires sampling and testing at a frequency greater than one per 90,000 ft², then the Geotextile Manufacturer shall pay for the cost of the additional CQA sampling and testing beyond one sample per 90,000 ft².
- D. The CQA Consultant may increase the frequency of sampling in the event that test results do not comply with requirements of Part 2.01 of this section. The Geotextile Manufacturer or CONTRACTOR shall bear the expense of this additional testing.
- E. Any geotextile that is not certified in accordance with Part 1.03 of this section, or that conformance testing indicates does not comply with Part 2.01 of this section, will be rejected by the CQA Consultant. The Geotextile Manufacturer shall replace the rejected material with new material, at no additional cost to OWNER.

PART 3 - Execution

3.1 Preparation

- A. Construct the surface underlying the geotextiles smooth and free of ruts or protrusions which could damage the geotextiles.

3.2 Installation

- A. Install geotextiles in accordance with manufacturer's written recommendations.
- B. Handling shall be in accordance with ASTM D4873.
- C. No equipment will be permitted to traffic in direct contact with the geotextile.
- D. Lay geotextile smooth so as to be free of tensile stresses, folds, and wrinkles.
- E. Protect geotextiles from clogging, tears, and other damage during installation.
- F. Overlapping geotextiles shall be thermally bonded.
- G. Geotextile Repair:

1. Place a patch of the same type of geotextile which extends a minimum of 12 inches beyond the edge of the damage or defect.
 2. Fasten patches continuously using thermal bonding, sewn seam or other approved method.
 3. Align machine direction of the patch with the machine direction of the geotextile being repaired.
 4. Replace geotextile which cannot be repaired.
- H. Use adequate ballast (e.g. sand bags) to prevent uplift by wind.
- I. Do not use staples or pins to hold the geotextile in place.
- J. Geotextile left uncovered for more than 14 days shall be removed and replaced at the Contractor's expense.

END OF SECTION