PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Furnishing, installation, quality control, and testing of a High Density Polyethylene (HDPE) or Flexible Polypropylene (fPP) geomembrane liner. The geomembrane system shall be a double liner system with a 200 mil geonet between the two layers to provide an interstitial space for collection of water which may leak through the first layer. A drain system shall be provided to collect leakage.

B. Related Sections include but are not necessarily limited to:
   1. Division 1 - General Requirements.
   2. Division 31 - Earthwork.
   3. Section 31 38 25 – Geotextiles
   4. Section 31 38 26 – Geonet

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      k. D4437, Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
      m. D5321, Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
q. D5721, Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.
r. D5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.

2. Environmental Protection Agency (USEPA):

3. Geosynthetic Research Institute (GRI):
a. GM11, Accelerated Weathering of Geomembranes Using a Fluorescent UVA-Condensation Exposure Device.
b. GM12, Asperity Measurement of Textured Geomembranes Using a Depth Gage.

B. Quality Assurance:
1. Contractor to hire independent inspector to conduct testing to support construction quality assurance program and to provide documentation of such to appropriate regulatory agencies.
   a. Facilitate and provide opportunities as required.
   b. Geomembrane Liner Inspection to be paid by Contractor.
2. Independent Testing Laboratory. It is the Contractor’s responsibility to provide and pay for an independent testing laboratory to conduct all required testing to support the construction quality and provide documentation to the appropriate regulatory agencies. The independent testing laboratory shall be approved by the Contracting Officer.
3. Unless specifically superseded by these contract documents or approved plans submitted by the Contractor, the geosynthetic materials shall be manufactured, stored, placed, seamed, tested and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.

C. Qualifications:
1. Each manufacturing and fabricating firm shall demonstrate 5 years continuous experience with a minimum of 10,000,000 SF of HDPE geomembranes or fPP geomembranes.
   a. For fPP, the manufacturing and fabricating firm shall also demonstrate at least 5 million square feet of scrim reinforced polypropylene material in the past 3 years.
2. Installer:
   a. Demonstrate 5 years continuous experience with a minimum 10,000,000 SF of HDPE geomembranes or fPP 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).
3. Inspectors:
   a. Demonstrate 3 years continuous experience in similar geosynthetic materials installation.
   b. Be an employee of an authorized representative for the Manufacturer and shall remain on the project throughout the entire construction of the HDPE geomembrane or fPP geomembrane.
4. Independent Testing Laboratory shall demonstrate 3 years of continuous experience in similar geosynthetic materials testing.
5. Installer shall attend pre-installation conference with Contracting Officer and Contractor to discuss details of geomembrane installation and coordinate related work.

D. Certifications:
   1. Certifications are required for various aspects of the project related to the 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.

1.3 DEFINITIONS

A. Manufacturer:
   1. Manufacturer producing geomembrane sheets from resin and additives.

B. Installer:
   1. The Installers are the individuals actually performing the hands-on work in the field.

C. Inspector:
   1. Inspectors of geomembrane are the individuals responsible for observing field installation of the geosynthetic materials and providing the Manufacturer, Fabricator, Installer and Contracting Officer 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. Independent Testing Laboratory:
   1. The firm hired by the Contractor to perform destructive testing of the geomembrane.
   2. Firm shall be acceptable to Contracting Officer.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Section 01 33 23.
   2. Submit for Contracting Officer's approval Shop Drawings, including:
      a. Manufacturer's certification that raw materials and sheet materials comply with required materials, mil thickness, and material properties.
         1) Original certificates are required.
      b. Manufacturer/Fabricator/Installer quality control requirements.
      c. Qualifications and experience of key personnel involved in installation/inspection of the geosynthetic materials and geosynthetic liner system.
d. Geomembrane 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 of testing geomembrane and other geosynthetic materials, joints and connections at appurtenances for continuity.
   4) Location and configuration of haul roads and access points.

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.
   2. Warranties as described below.
   3. Submit written certifications that:
      a. Utilize certification forms from this Section unless alternately approved.
         1) Make appropriate number of copies, as required.
      b. The geomembrane material delivered to site meets the requirements of this Specification.
      c. The geomembrane were received and accepted in undamaged condition from shipper.
      d. The subgrade has been properly prepared and acceptable for the placement of the geomembrane.
      e. The geomembrane liner was installed in accordance with this Specification and with approved Shop Drawings.
      f. The 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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Unused or stockpiled 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. Geomembrane or plastic wrapping damaged as a result of storage or handling shall be repaired or replaced, as directed by Contracting Officer.
   2. Geomembrane shall not be exposed to temperatures in excess of 60 DegC (140 DegF) or less if recommended by the Manufacturer.

C. No hooks, tongs or other sharp instruments shall be used for handling the geomembrane.
   1. Rolls shall not be lifted by use of cables or chains in contact with the geomembrane.
   2. Geomembrane shall not be dragged along the ground.

1.6 WARRANTY

A. Written warranties addressing geomembrane material and installation workmanship shall be furnished by the Contractor and shall be made to the Government.

B. Submit material samples and warranties prior to shipment.
C. Suitability of geosynthetic liner system shall be subject to Contracting Officer approval of warranty.  
   1. The Manufacturer's warranty shall state that the furnished material meets all requirements of the Contract Drawings and Specifications, and that under exposure to liquids identified in the Contract Documents and local atmospheric conditions the sheet material is warranted for 20 years, prorated.  
   2. The Installer's warranty shall state that the materials were properly installed, properly (field and factory) welded, seamed and jointed and will not fail within two years of the installation.  
      a. Warranty shall not be prorated.  
D. Warranties shall provide for complete repair/replacement at no additional cost to the Government for the warranty period.  

1.7 PROJECT/SITE 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 or hot temperatures, or other weather elements, the installation shall be halted until the weather conditions are satisfactory.  
B. The Contractor shall ensure that adequate dust control methods are in effect to prevent the unnecessary accumulation of dust and dirt on surfaces which hamper efficient field seaming or performance.  
C. Maintain 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. Vehicles, other than those specifically approved by the Contracting Officer, will not be allowed on geomembrane liner.  

PART 2 - PRODUCTS  

2.1 ACCEPTABLE MANUFACTURERS  
A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:  
   1. HDPE Geomembrane liners:  
      c. Or approved equal.  
   2. fPP Geomembrane liners:  
      a. Carlisle SynTec, Inc., P.O. Box 7000, Carlisle, Pennsylvania 17013 (800-4-SYNTEC).  
      b. Or approved equal.  

2.2 MATERIALS  
A. HDPE Geomembrane Liner:  
   1. Consisting of two layers of unreinforced polyethylene with a 200 mil geonet liner in between to provide an interstitial space.  
      a. Primary liner minimum thickness: 60 mils.  
      b. Secondary liner minimum thickness: 40 mils.
c. Manufactured from virgin, first quality resin designed and formulated specifically for liquid containment in hydraulic structures.
d. Reclaimed polymer shall not be added to the resin; except use of polymer recycled during the manufacturing process shall be allowed provided that recycled polymer shall be clean and shall not exceed 2 percent by weight.
e. No additives or fillers may be added to the resin prior to or during manufacture of the HDPE geomembrane.
f. A 200 mil geonet layer between primary and secondary geomembrane liner is required.
2. 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 Manufacturer's recommendations if approved by the Contracting Officer.
3. Manufactured as seamless rolls or as prefabricated panels.
a. Minimum width: 15 FT as delivered to the site.
b. All factory seams shall be inspected and tested for strength and continuity prior to delivery to the site.
4. Specifications:
a. HDPE geomembrane shall be textured both sides.
b. Textured HDPE geomembrane shall possess properties which meet or exceed the following minimum requirements:
<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>TEST VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (min avg)</td>
<td>D5994</td>
<td>Primary: 60 mils nom. (-5%)</td>
</tr>
<tr>
<td>-lowest indiv for 8 out of 10 values</td>
<td></td>
<td>Secondary: 40 mils nom. (-5%)</td>
</tr>
<tr>
<td>-lowest indiv for any of the 10 values</td>
<td></td>
<td>-10%</td>
</tr>
<tr>
<td>-15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asperity Height (minimum average)</td>
<td>GM12</td>
<td>7 mil</td>
</tr>
<tr>
<td>Density (min avg)</td>
<td>D1505/D792</td>
<td>0.940 g/cc</td>
</tr>
<tr>
<td>Tensile Properties (min avg)</td>
<td>D6693</td>
<td></td>
</tr>
<tr>
<td>Type IV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-yield stress</td>
<td></td>
<td>126 lb/in</td>
</tr>
<tr>
<td>-break stress</td>
<td></td>
<td>90 lb/in</td>
</tr>
<tr>
<td>-yield elongation</td>
<td></td>
<td>12%</td>
</tr>
<tr>
<td>-break elongation</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Tear Resistance (min avg)</td>
<td>D1004</td>
<td>42 lb</td>
</tr>
<tr>
<td>Puncture Resistance (min avg)</td>
<td>D4833</td>
<td>90 lbs</td>
</tr>
<tr>
<td>Stress Crack Resistance (2)</td>
<td>D5397</td>
<td>200 hr</td>
</tr>
<tr>
<td>Carbon Black Content (range)</td>
<td>D1603(3)</td>
<td>2.0-3.0%</td>
</tr>
<tr>
<td>Carbon Black Dispersion</td>
<td>D5596</td>
<td>Note (4)</td>
</tr>
<tr>
<td>Oxidative Induction Time (OIT) (min avg) (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Standard OIT, or</td>
<td>D3895</td>
<td>100 min</td>
</tr>
<tr>
<td>(b) High Pressure OIT</td>
<td>D5885</td>
<td>400 min</td>
</tr>
<tr>
<td>Oven Aging at 85 degC (5),(6)</td>
<td>D5721</td>
<td></td>
</tr>
<tr>
<td>(a) Standard OIT (min avg), or</td>
<td>D3895</td>
<td>55%</td>
</tr>
<tr>
<td>(b) High Pressure OIT (min avg)</td>
<td>D5885</td>
<td>80%</td>
</tr>
<tr>
<td>% retained after 90 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV Resistance (7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) High Pressure OIT (min avg)</td>
<td>GM11</td>
<td>N.R. (8)</td>
</tr>
<tr>
<td>% retained after 90 days</td>
<td>D5885</td>
<td>60%</td>
</tr>
</tbody>
</table>
(1) Machine direction (MD) and cross machine direction (XMD) average values shall be on the basis of 5 test specimens each direction:
   (a) Yield elongation is calculated using a gage length of 1.3 IN.
   (b) Break elongation is calculated using a gage length of 2.0 IN.
(2) The SP-NCTL test shall be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
   (a) The yield stress used to calculate the applied load for the SP-NCTL test shall be the manufacturer's mean value via MQC testing.
(3) Other methods such as ASTM D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to ASTM D1603 (tube furnace) has been established.
(4) Carbon black dispersion for 10 different views:
   (a) Minimum 8 of 10 in Categories 1 or 2.
   (b) All 10 in Categories 1, 2, or 3.
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate supplies at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 HR UV cycle at 75 DegC followed by 4 HR condensation at 60 DegC.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

B. fPP Geomembrane Liner:
1. Consists of two layers of flexible polypropylene (fPP) with a 200 mil geonet liner in between to provide an interstitial space.
   a. Minimum thickness: 45 mils.
   b. Scrim-reinforced.
   c. Manufactured from virgin, first quality resin designed and formulated specifically for liquid containment in hydraulic structures.
   d. Reclaimed polymer shall not be added to the resin; except use of polymer recycled during the manufacturing process shall be allowed provided that recycled polymer shall be clean and shall not exceed 2 percent by weight.
   e. No additives or fillers may be added to the resin prior to or during manufacture of the fPP geomembrane.
   f. A 200 mil geonet layer between primary and secondary geomembrane liner is required.
2. Reinforcing:
   a. Finished membrane shall consist of 2 plies of polypropylene laminated over 1 ply of reinforcing scrim.
   b. Reinforcing shall be a polyester scrim to create an open type weave that permits strike-through of the polypropylene.
   c. Polypropylene shall fully encapsulate the scrim and shall extend a minimum of 1/8 IN beyond the reinforcing scrim roll edges.
3. Exposed fabric along the longitudinal edges of the roll stock shall not be permitted.
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 Manufacturer's recommendations if approved by the Contracting Officer.
5. Manufactured as seamless rolls or as prefabricated panels.
   a. Minimum width: 12 FT as delivered to the site.
   b. All factory seams shall be inspected and tested for strength and continuity prior to delivery to the site.
6. Specifications:
   a. Textured fPP geomembrane shall possess properties which meet or exceed the following minimum requirements:
<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>TEST VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (min ave.)</td>
<td>ASTM D5199</td>
<td>45 mils nom. (-5%)</td>
</tr>
<tr>
<td>- lowest indiv. for 8 out of 10 values</td>
<td></td>
<td>-10 %</td>
</tr>
<tr>
<td>- lowest indiv. for any of the 10 values</td>
<td></td>
<td>-15 %</td>
</tr>
<tr>
<td>Breaking Strength – Fabric, minimum (lbf)</td>
<td>ASTM D751</td>
<td>250x250 lbs.</td>
</tr>
<tr>
<td>Mass per unit area</td>
<td>ASTM D5261</td>
<td>0.20 (92)(1.00) Minimum</td>
</tr>
<tr>
<td>Lb/ft² (g/ft²)(kg/m²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Temperature Flexibility</td>
<td>ASTM D2136, 1/8 IN mandrel rel. 4 hrs - pass</td>
<td>-40 (°F)</td>
</tr>
<tr>
<td>Puncture Resistance (lbs) (N)</td>
<td>ASTM D4833, index puncture</td>
<td>110 (489) typical</td>
</tr>
<tr>
<td>Tear Strength, minimum (lbf)</td>
<td>ASTM D751, Method B Tongue Tear</td>
<td>70</td>
</tr>
<tr>
<td>Dimensional Stability (% change, maximum)</td>
<td>ASTM D1204</td>
<td>180°F/1 hour</td>
</tr>
<tr>
<td>Hydrostatic resistance minimum (psi)</td>
<td>ASTM D751, Method A, Procedure 1</td>
<td>350</td>
</tr>
<tr>
<td>Ply adhesion, minimum (lbs/in)</td>
<td>ASTM D413, Machine Method Modified</td>
<td>20</td>
</tr>
<tr>
<td>Water Adsorption (% weight change, maximum)</td>
<td>ASTM D471, 30 days @ 122°F</td>
<td>1%</td>
</tr>
<tr>
<td>UV Resistance</td>
<td>ASTM G26 Xenon Arc Method 80°C</td>
<td>Pass 10,000 hours</td>
</tr>
<tr>
<td>Stress Cracking Resistance (min. hours with no failure)</td>
<td>ASTM D1693</td>
<td>Pass 3,000 hours</td>
</tr>
<tr>
<td>Bonded Seam Strength (lbs/inch)</td>
<td>ASTM D751, as Modified in Annex A, NSF 61</td>
<td>200</td>
</tr>
<tr>
<td>Peel Adhesion, minimum (lbs/inch)</td>
<td>ASTM D413, as modified In Annex A, NSF 61</td>
<td>20 or FTB</td>
</tr>
</tbody>
</table>
(1) The SP-NCTL test shall be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
   (a) The yield stress used to calculate the applied load for the SP-NCTL test shall be the manufacturer's mean value via MQC testing.

2.3 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 on the geomembrane.

B. Field Tensiometer:
   1. Provide a tensiometer for on-site shear and peel testing of 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.
   2. Tension meter:
      a. Motor driven.
      b. Jaws capable of traveling a measure rate of 2 IN 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 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.

2.4 FABRICATION

A. Produce geomembrane sheet which complies with this Specification.

B. Provide resin and additive quality control:
   1. Test raw resin and additives to ensure compliance with the Manufacturer's specifications and with this Specification.
2. Test sheet material to ensure compliance with Manufacturer's specification and this Specification.
3. Provide certification of the raw materials and finished sheet demonstrating compliance with this Specification.
4. Provide certification of Fabricator's and Installer's training (unless Installer is certified by other acceptable manufacturer list herein), experience and methods for welding, seaming, jointing and inspecting geosynthetic materials installations in compliance with Manufacturer's standards and with Quality Assurance requirements of this Specification (Article 1.2).

C. Fabricated Specials:
   1. Subject to same level of manufacturer's quality control.
   2. Fabricated from project rolls.
      a. Provide traceability of resin and roll stock.

D. Factory seams:
   1. Seams shall be made by thermal fusion methods.
   2. Minimum scrim-to-scrim overlap of 1.5 IN when fabricated.
   3. Thermal fusion bond extends fully to the top edge of the sheet so that no more than 1/8 IN loose edge is present on the top side of the sheet and is pointing downslope.
      a. Top sheet shall be placed “upslope” of the bottom sheet.

PART 3 - EXECUTION

3.1 GEOMEMBRANE LINER SYSTEM

A. Geomembrane Subgrade:
   1. After ponds are emptied of wastewater and solids and cleaned, Contractor to inspect.
      After installation of new piping and appurtenances at Pond 1, install a new liner system.
      See Specification Section 31 38 25 for geotextile fabric requirements.
   2. Protect subgrade at all times from damage until such time as the placement of geomembrane liner and other components of the geosynthetic liner system are complete.
   3. The subgrade shall be respectively prepared in a manner consistent with proper subgrade preparation techniques for the installation of either HDPE or iPP geomembrane.
      a. The subgrade shall be properly compacted so as not to settle and cause excessive strains in the geomembrane or other synthetic liner materials.
      b. Prior to liner installation, ensure a surface free of debris, roots, or angular stones larger than 1/2 inch or debris that may puncture the geomembrane. The top 2 inches of prepared subgrade shall be free of any materials that may damage the liner.
      c. In addition, ensure that the subgrade has been rolled to provide a uniform surface.
d. During installation, ensure that rutting or raveling is not caused by installation equipment or weathering.

6. All earthen surfaces shall be compacted and smooth graded with anchor trenches provided as required.

7. Subgrade shall be compacted to a minimum of 95% of the dry density (as determined by ASTM D698 Standard Proctor Method).

8. All vegetation shall be removed from the surface to be lined.

9. If groundwater is present within 12 IN below the surface to be lined, the Contractor shall dewater the area prior to and during the installation of the liner.

10. The completed subgrade and finished grades shall be within ±0.1 FT of the specified elevation. The Contractor shall provide an as-built grading survey to the Contracting Officer demonstrating grades within this tolerance.

11. The company installing the liner shall provide a certification for each pond stating that the subgrade/asphalt surface is suitable and acceptable for the liner system.

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 to manufacture specifications and industry standard.

C. Geomembrane:

1. General:
   a. Installer of geomembranes is responsible for handling, fitting, welding, seaming, jointing and testing of geosynthetic materials sheets or blankets in the field.

   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 soil subgrade or asphalt which will serve as a base for the geomembrane.
         a) This acceptance shall precede installation of the 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 geomembrane liners.
         c) Shall explicitly state any and all exceptions to acceptance.
      3) Handling, welding, seaming, jointing, testing and repair of geomembrane liners and other geosynthetic materials in compliance with this Specification and with written procedures manuals prepared by the Manufacturer or Fabricator.
         a) Manual shall be submitted to the Contracting Officer together with Shop Drawings showing the layout of geomembrane within the facility. (1) Do not deviate from the procedures included in the manual.
         b) Geomembrane shall not be placed upon frozen foundation, standing water or other conditions which will result in deterioration of the foundation.
         c) Geomembrane liner materials shall be laid out according to plans previously approved by the Contracting Officer.
         d) Adjacent rolls of geomembrane shall overlap a minimum of 3 IN, 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 Contracting Officer.
5) Installer and Manufacturer may be the same firm.

2. 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.
   c. Equipment used to deploy the geomembrane shall not rut the subgrade.
   d. No vehicular traffic is permitted on unprotected geomembrane.
   e. Minimize foot traffic.
      1) Do not allow personnel access to wet or slippery liners without adequate safety precautions.
   f. Ballast with sandbags to prevent wind uplift as recommended by Manufacturer and Fabricator and based on local climatic conditions.
      1) Remove and replace all wind damaged panels at no additional cost to Government.
      2) If wind causes panels to be displaced, displaced panel may not be reused.
   g. Install 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 geomembrane to bubble, fold, or create ripples as a result of deployment.
      1) Except as noted on Contract Drawings no folds in 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 geomembrane shall cause termination of seaming operations.
         b) Geomembrane shall not be seamed when ambient temperatures are below 41 DegF or above 104 DegF, without written consent of geomembrane Manufacturer or Fabricator, and Contracting Officer.
   5) 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 IN.
      c) Areas of the slit which do not achieve an overlap of 6 IN, including the terminus of the slit, shall be provided with a patch as discussed below.
6) All geomembranes shall be seamed by thermal fusion methods as recommended by the geomembrane Manufacturer.
   a) Geomembrane seaming shall be double wedge weld unless otherwise approved or prohibited by construction.

7) Manufacturer's or Fabricator'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 or Fabricator's seaming instructions shall be available on site at all times and shall not be deviated from without written approval of the Manufacturer and Contracting Officer.

9) All panels/sheets should be overlapped a minimum of 3 IN.
   a) Seams that are purely horizontal are not allowed.

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 geomembrane.

k. Patching:

1) Defects in and damage to geomembrane sheets shall be repaired by seaming a patch over the defect.
   a) The patch material shall consist of an undamaged piece of geomembrane cut to provide a minimum of 6 IN of overlap in all directions from the defect.
   b) Round corners shall be utilized on all patches.
      (1) No bead or spot patching will be accepted.
   c) Torn or permanently twisted geomembrane shall be replaced at no additional expense to the Government.

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.

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 Fabricator and Installer.
   1. Inspectors responsibilities include, but are not limited to:
      a. Inspection of the material and the handling and field installation of the geomembrane.
         1) Inspection of all welds, repairs and quality control test results.
      b. All exceptions to material or installation shall be documented and furnished to the Contracting Officer in writing within 48 HRS of discovery.

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. Samples shall be tested in accordance with ASTM D413 and ASTM D882.
   a. To be acceptable, five of five replicate test specimens must meet specified seam strength requirements and failures shall be Film Tear Bond.
   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.
      1) 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; ultrasonic tests; spark tests; and pressurized air channel test.

D. Destructive Seam Testing:
1. A minimum of one destructive test sample in each transverse field seam, and as many other samples as Contracting Officer determines appropriate, shall be obtained at locations specified by the Contracting Officer.
   a. Sample locations shall not be identified prior to seaming.
   b. The samples shall be a minimum of 12 IN wide by 48 IN long with the seam centered lengthwise.
   c. Each sample shall be cut into three equal pieces with one piece retained by the Installer, one piece given to an Independent Testing Laboratory, and the remaining piece given to the Contracting 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 IN 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.
      1) Jaw separation speed shall be 2 IN 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 Independent 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.

3. The minimum required seam strengths:

<table>
<thead>
<tr>
<th>MINIMUM MODE</th>
<th>TEST METHOD</th>
<th>VALUE (LBS/IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear</td>
<td>ASTM D816</td>
<td>120</td>
</tr>
</tbody>
</table>

4. If the field tests pass, 5 specimens shall be tested at the Independent 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 Contracting Officer prior to acceptance of the seam.

5. Ten percent of all repaired areas shall be destructively tested.

a. All other repaired areas shall be non-destructively tested.

6. Destructive testing shall be performed by an Independent Testing Laboratory employed by the Contractor, not the Installer.

a. The Contracting Officer may separately conduct destructive testing for quality assurance.

b. If samples tested by Contracting Officer fail, based on above criteria, the seam will be classified as failed.

7. A map showing the locations, number and type of all patches shall be prepared and provided to the Contracting Officer.

3.3 GEOSYNTHETIC LINER SYSTEM ACCEPTANCE

A. Contractor shall retain all ownership and responsibility for the geosynthetic liner system until final acceptance by the Contracting Officer.

1. Contracting Officer 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.

3.4 SCHEDULE OF CERTIFICATIONS

A. The schedule of required certifications and signing parties follows the end of this Section.

B. The certificates following the end of this Section shall be completed and signed by the required parties, and the original certificates delivered to the Contracting Officer's representative as a part of the completion of that particular phase of the geosynthetic liner system installation.
<table>
<thead>
<tr>
<th>CERTIFICATE</th>
<th>SIGNATURES REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Certification of Raw and Fabricated Material</td>
<td>Manufacturer Fabricator</td>
</tr>
<tr>
<td>2. Certification of Material Acceptance from Shipper</td>
<td>Installer Contractor</td>
</tr>
<tr>
<td>3. Certification of Acceptance of Subgrade</td>
<td>Installer Inspector Contractor</td>
</tr>
<tr>
<td>4. Certification of Material Installation</td>
<td>Installer Inspector Contractor</td>
</tr>
<tr>
<td>5. Certification of Material Joints</td>
<td>Installer Inspector Contractor</td>
</tr>
<tr>
<td>6. Certification of Placement of Adjacent Liner Components</td>
<td>Installer Inspector Contractor</td>
</tr>
</tbody>
</table>
CERTIFICATION OF RAW AND FABRICATED MATERIAL
(To Accompany Each Shipment) (Circle Material Type)

DATE: __________________________

MATERIAL DESCRIPTION:

_________________________________________________________
(include lot and roll/panel numbers)

WE THE UNDERSIGNED CERTIFY THAT THE RAW MATERIAL AND FINISHED
[GEOMEMBRANE LINER MATERIAL, GEOTEXTILES] FURNISHED FOR THE NATIONAL
PARK SERVICE PROJECT

______________________________
MANUFACTURER NAME

______________________________
MANUFACTURER SIGNATURE (Authorized Representative)

______________________________
FABRICATOR NAME

______________________________
FABRICATOR SIGNATURE (Authorized Representative, if different from Manufacturer)
CERTIFICATION OF MATERIAL ACCEPTANCE FROM SHIPPER
(Per shipment; each roll or container) (Circle Material Type)

REPORT NO.:_____________________________ DATE:_____________________________

PANEL, ROLL, AND CONTAINER NUMBER REFERENCES_____________________________

WE THE UNDERSIGNED ACCEPT THE [GEOMEMBRANE LINER MATERIALS (ROLLS,
SHEETS, BLANKETS), GEOTEXTILES], FROM THE TRANSPORTER. THESE
MATERIALS WERE RECEIVED IN UNDAMAGED CONDITION BASED UPON OUR
VISUAL INSPECTION.

____________________________________
INSTALLER SIGNATURE

____________________________________
CONTRACTOR SIGNATURE
CERTIFICATION OF ACCEPTANCE OF SUBGRADE – Daily Certification
(Circle Material Type)

REPORT NO.:_________ DATE:_____________________

AREA REFERENCED:____________________________________________________________

______________________________

LINER PANEL NUMBERS INSTALLED OVER REFERENCED AREA THIS DATE:

______________________________

WE THE UNDERSIGNED CERTIFY THAT WE HAVE INSPECTED THE ENTIRE SURFACE,
AND HAVE REVIEWED THE SPECIFICATION SECTION 31 38 10 AND RELATED SHOP
DRAWINGS FOR MATERIAL AND PLACEMENT, AND FIND ALL CONDITIONS
ACCEPTABLE FOR PLACEMENT OF THE GEOMEMBRANE LINER.

WE SPECIFICALLY TAKE THE FOLLOWING EXCEPTIONS TO THE ACCEPTANCE OF THE
SUBGRADE ON THIS DATE:

______________________________

(Note: All exceptions shall be approved by Contracting Officer prior to Geomembrane Liner
Installation)

______________________________

INSTALLER SIGNATURE

______________________________

INSPECTOR SIGNATURE

______________________________

CONTRACTOR SIGNATURE
LAKE MEAD NATIONAL RECREATION AREA

CERTIFICATE OF MATERIAL INSTALLATION - Daily Certification
(Circle Material Type)

REPORT NO.: ___________ DATE: _________________________

AREA REFERENCED: _______________________________________

________________________________________________________________

LINER PANEL NUMBERS INSTALLED THIS DATE: _______________________

________________________________________________________________

WE THE UNDERSIGNED CERTIFY THAT THE [GEOMEMBRANE LINER, GEOTEXTILES] WAS INSTALLED IN ACCORDANCE WITH THE SPECIFICATION SECTION [31 38 10] AND WITH APPROVED SHOP DRAWINGS.

________________________________________________________________

INSTALLER SIGNATURE

________________________________________________________________

INSPECTOR SIGNATURE

________________________________________________________________

CONTRACTOR SIGNATURE
CERTIFICATION OF MATERIAL JOINTS - Daily Certification Per Test
(As Shop Drawings and as a Compiled Report at the end of Project)
(Circle Material Type)

TEST REPORT NO.: ___________ DATE: ______________

FIELD LOG NO.: _______________

LIST OF ALL DEFICIENCIES AND SUBSEQUENT REPAIRS, COPIES OF ALL FIELD AND FACTORY TESTS AND INSPECTION DATA INCLUDING RECORDS OF ALL NON-DESTRUCTIVE TESTING (Field Logs) AND REPAIRS ARE ATTACHED.


________________________________________
INSTALLER SIGNATURE

________________________________________
INSPECTOR SIGNATURE

________________________________________
CONTRACTOR SIGNATURE
CERTIFICATION OF PLACEMENT OF ADJACENT LINER COMPONENTS – Daily
Certifications; Per Material and Location (Circle Material Type)

REPORT NO.: __________  DATE: ____________________

COMPONENT BEING PLACED: __________________________________________________________________

SUBSTRATE: ____________________________________________________________________________

LOCATION: ____________________________________________________________________________

WE THE Undersigned certify that the [Geotextile, Drainage Layer, Protective Soil Cover] on top of the [Geomembrane Liner, Geotextile] was carefully placed under my direct supervision/observation this date, and without damaging any of the underlying or adjacent substrate.

________________________
INSTALLER SIGNATURE

________________________
INSPECTOR SIGNATURE

________________________
contractor signature

END OF SECTION 31 38 10
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Nonwoven geotextile material.

B. Related Specification Sections include but are not necessarily limited to:
   1. Section 31 38 10 - Geomembrane Liner.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Association of State Highway Transportation Officials (AASHTO):
   2. ASTM International (ASTM):
      i. D4873, Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.

B. Qualifications:
   1. Each manufacturing, fabricating firm shall demonstrate five (5) years continuous experience, including a minimum of 10,000,000 SF of geotextile installation in the past three (3) years.
   2. Installing firm shall demonstrate that the site Superintendent or Foreman has had responsible charge for installation of a minimum of 1,000,000 SF of geotextile.
   3. Installer shall attend pre-installation conference with Contracting Officer and Contractor to discuss details of geotextile installation and coordinate related work.
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.

1.4 SUBMITTALS
A. Shop Drawings:
   1. See Specification for requirements for the mechanics and administration of the submittal process.
   2. Manufacturer's documentation that raw materials and roll materials comply with required geotextile physical properties.
   3. Manufacturer and Installer quality control manuals.
   4. Original test results for resins, roll material and factory seam tests at frequency specified in respective quality control manuals.
      a. Results shall include or bracket the rolls delivered for use in the Work.
   5. Geotextile layout plan with proposed size, number, position and sequencing of geotextile rolls and direction of all field seams.
   6. Proposed details of anchoring and overlapping if different than included in Contract Documents.

B. Miscellaneous Submittals:
   1. See Specification for requirements for the mechanics and administration of the submittal process.
   2. Provide same certifications specified in Specification Section 31 38 10.
      a. No alterations, additions, deletions, or exception shall be made to the specified language.
   3. 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.
   4. Qualification documentation specified in the QUALITY ASSURANCE Article in PART 1 of this Specification Section.

1.5 DELIVERY, STORAGE AND HANDLING
A. See Specification Section 01 67 00.
B. Label, handle, and store geotextiles in accordance with ASTM D4873 and as specified herein.
C. Wrap each roll in an opaque and waterproof layer of plastic during shipment and storage.
   1. Do not remove the plastic wrapping until deployment.
D. Label each roll with the manufacturer's name, geotextile type, lot number, roll number, and roll dimensions (length, width, gross weight).
E. Repair or replace geotextile or plastic wrapping damaged as a result of storage or handling, as directed.
F. 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.
G. Do not use hooks, tongs or other sharp instruments for handling geotextile.
1. Do not lift rolls lifted by use of cables or chains in contact with the geotextile.
2. 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. Propex Geosynthetics.
   3. SKAPS Industries.
   4. TenCate Mirafi.
   5. Tenax.
   6. Or approved equal.

B. Submit request for substitution in accordance with Specification.

2.2 MATERIALS AND MANUFACTURE

A. Geotextile:
   1. Nonwoven 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.
   4. The geotextile physical properties shall equal or exceed the minimum average roll values listed below.
      a. Values shown are for the weaker principal direction.
      b. Acceptance of geotextile shall be in accordance with ASTM D4759.
      c. Type I Geotextile: AASHTO M288 Class 2, for use as geomembrane underlayment and as shown on Drawings.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>MINIMUM AVERAGE ROLL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass per Unit Area, OZ/SY</td>
<td>ASTM D5261</td>
<td>16</td>
</tr>
<tr>
<td>AOS, U.S. Standard Sieve</td>
<td>ASTM D4751</td>
<td>100</td>
</tr>
<tr>
<td>Permittivity, SEC-1</td>
<td>ASTM D4491</td>
<td>0.6</td>
</tr>
<tr>
<td>Puncture, LBS</td>
<td>ASTM D4833</td>
<td>155</td>
</tr>
<tr>
<td>Grab Tensile, LBS</td>
<td>ASTM D4632</td>
<td>270</td>
</tr>
<tr>
<td>Trapezoidal Tear, LBS</td>
<td>ASTM</td>
<td>100</td>
</tr>
</tbody>
</table>
d. Type 2 Geotextile: AASHTO M288 Class 2, for use under crushed base course and other areas shown on the Drawings.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>MINIMUM AVERAGE ROLL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burst Strength, PSI</td>
<td>ASTM D4533</td>
<td>=500</td>
</tr>
<tr>
<td>Ultraviolet Degradation % retained @ 500 HRS</td>
<td>ASTM D3786</td>
<td>=70</td>
</tr>
<tr>
<td>Sewn Seam Strength, LBS</td>
<td>ASTM D4355</td>
<td>=270</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>MINIMUM AVERAGE ROLL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass per Unit Area, OZ/SY</td>
<td>ASTM D5261</td>
<td>=8</td>
</tr>
<tr>
<td>AOS, U.S. Standard Sieve</td>
<td>ASTM D4751</td>
<td>70-100</td>
</tr>
<tr>
<td>Permittivity, SEC-1</td>
<td>ASTM D4491</td>
<td>=1.3</td>
</tr>
<tr>
<td>Puncture, LBS</td>
<td>ASTM D4833</td>
<td>=90</td>
</tr>
<tr>
<td>Grab Tensile, LBS</td>
<td>ASTM D4632</td>
<td>=250</td>
</tr>
<tr>
<td>Trapezoidal Tear, LBS</td>
<td>ASTM D4533</td>
<td>=90</td>
</tr>
<tr>
<td>Burst Strength, PSI</td>
<td>ASTM D3786</td>
<td>=190</td>
</tr>
<tr>
<td>Ultraviolet Degradation % retained @ 500 HRS</td>
<td>ASTM D4355</td>
<td>=50</td>
</tr>
<tr>
<td>Sewn Seam Strength, LBS</td>
<td>ASTM D4632</td>
<td>=220</td>
</tr>
</tbody>
</table>

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.

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. Hand place geotextile.
1. No equipment will be permitted in direct contact with the geotextile.

C. Lay geotextile smooth so as to be free of tensile stresses, folds, and wrinkles.

D. Seam Construction:
   1. Sew all Type I geotextile seams.
   2. Broom clean existing geotextile and cut off to provide a clean area for seaming with the new geotextile.
   3. Sew seams continuously using an SSA flat seam with one (1) row of a two-thread 401 chain stitch unless otherwise recommended by the manufacturer.
   4. Minimum distance from the geotextile edge to the stitch line nearest to that edge: 2 IN unless otherwise recommended by the manufacturer.
   5. Test seams at the frequency specified in the FIELD QUALITY CONTROL Article in PART 3 of this Specification Section.
   6. Tie off thread at the end of each seam to prevent unraveling.
   7. Construct seams on the top side of the geotextile to allow inspection.
   8. Sew skipped stitches or discontinuities with an extra line of stitching with 18 IN of overlap.
   9. Type 2 geotextile seams may be sewn or overlapped.
      a. Construct overlapped seams in accordance with manufacturer's recommendations or as shown on Drawings.

E. Heat tack the geotextile overlaps as shown on the Drawings.

F. Backfill anchor trenches

G. Place cover soil

H. Protect geotextiles from clogging, tears, and other damage during installation.

I. Geotextile Repair:
   1. Place a patch of the same type of geotextile which extends a minimum of 12 IN beyond the edge of the damage or defect.
   2. Fasten patches continuously using a 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.

J. Use adequate ballast (e.g., sand bags) to prevent uplift by wind.

K. Do not use staples or pins to hold the geotextile in place.

L. Do not leave geotextile uncovered for more than 14 days.

3.3 FIELD QUALITY CONTROL

A. Conduct destructive seam testing at locations identified by the Contracting Officer.
   1. Minimum testing will be at a frequency of one (1) test per 2,000 linear feet of seam.

B. Provide as-constructed drawing showing roll number; layout; joint locations; and destructive sample repair, and patch locations.

END OF SECTION 31 38 25
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. 200 mil geonet drainage layer.

B. Related Specification Sections include but are not necessarily limited to:
   1.
   2. Section 31 38 10 - Geomebrane Liner

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society for Testing and Materials (ASTM)
      a. ASTM D 1238-01 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
      d. ASTM D 4716-00 Standard Test Method for Determining the (In-Plane) Flow
         Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a
         Constant Head
      e. ASTM D 5035-95 Standard Test Method for Breaking Force and Elongation of
         Textile Fabrics (Strip Method)
      f. ASTM D 5199-99 Standard Test Method for Measuring Nominal Thickness of
         Geotextiles and Geomembranes
   2. Relevant publications from the Environmental Protection Agency (EPA):
         Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-
         93/182.

1.3 DEFINITIONS

A. Construction Quality Assurance Consultant (Consultant) - Party, independent from
   Manufacturer and Installer that is responsible for observing and documenting activities
   related to quality assurance during the lining system construction.

B. Engineer - The individual or firm responsible for the design and preparation
   of the project’s Contract Drawings and Specifications.

C. Geonet Manufacturer (Manufacturer) - The party responsible for
   manufacturing the geonet rolls.

D. Geosynthetic Quality Assurance Laboratory (TESTING LABORATORY)-
   Party, independent from the Manufacturer and Installer,
   responsible for conducting laboratory tests on samples of geosynthetics
   obtained at the site or during manufacturing, usually under the direction of
   the Contracting Officer.

E. Installer- Party responsible for field handling, transporting, storing and
deploying the geonet.
F. Lot- A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geonet rolls. The finished rolls will be identified by a roll number traceable to the resin lot.

1.4 QUALIFICATIONS

A. Manufacturer
1. Geonet shall be manufactured by the following:
   a. GSE Lining Technology, Inc.
   b. Or approved equal
2. Manufacturer shall have manufactured a minimum of 10,000,000 square feet of polyethylene geonet material during the last year.

B. Installer
1. Installation shall be performed by one of the following installation companies (or approved equal):
   a. GSE Lining Technology, Inc.
   b. GSE Approved Dealer/ Installer
   c. Or approved equal.
2. Installer shall have installed a minimum of 1,000,000 square feet of geonet.
3. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.
4. Installer shall attend pre-installation conference with Contracting Officer and Contractor to discuss details of geonet installation and coordinate related work.

1.5 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

A. Labeling- Each roll of geonet delivered to the site shall be labeled by the Manufacturer. The label will identify:
   1. Manufacturer’s name
   2. Product identification
   3. Length
   4. Width
   5. Roll number

B. Delivery- Rolls of geonet will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage- The on-site storage location for the geonet, provided by the Contractor to protect the geonet from abrasions, excessive dirt and moisture shall have the following characteristics:
   1. Level (no wooden pallets)
   2. Smooth
   3. Protected from theft and vandalism
   4. Adjacent to the area being lined.

D. Handling
1. The Contractor and Installer shall handle all geonet in such a manner as to ensure it is not damaged in any way.
2. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geonet.
1.6 WARRANTY

A. Material shall be warranted, on a pro-rata basis against defects for a period of 1-year from the date of the geonet installation.
B. Installation shall be warranted against defects in workmanship for a period of 1-year from the date of geonet completion.

PART 2- PRODUCTS

2.1 GEONET PROPERTIES

A. A geonet shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure.
B. Thickness: 200 mil
C. The geonet specified shall have properties that meet or exceed the values listed in the following tables below.

Table 2.1A: Geonet Properties

<table>
<thead>
<tr>
<th>Tested Property</th>
<th>Test Method</th>
<th>Frequency</th>
<th>Minimum Average Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmissivity(^{(1)}), gal/min/ft (m^2/sec)</td>
<td>ASTM D 4716</td>
<td>1/540,000 ft²</td>
<td>9.66 ((2 \times 10^{-3}))</td>
</tr>
<tr>
<td>Density, g/cm(^3)</td>
<td>ASTM D 1505</td>
<td>1/50,000 ft²</td>
<td>0.94</td>
</tr>
<tr>
<td>Tensile Strength (MD), lb/in (N/mm)</td>
<td>ASTM D 5035/7179</td>
<td>1/50,000 ft²</td>
<td>45 (7.9)</td>
</tr>
<tr>
<td>Carbon Black Content, %</td>
<td>ASTM D</td>
<td>1/50,000 ft²</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Nominal Roll Dimensions**

<table>
<thead>
<tr>
<th>Geonet Thickness, mil (mm)</th>
<th>ASTM D 5199</th>
<th>1/50,000 ft²</th>
<th>200 ((5))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll Width(^{(2)}), ft (m)</td>
<td></td>
<td></td>
<td>15 ((4.5))</td>
</tr>
<tr>
<td>Roll Length(^{(2)}), ft (m)</td>
<td></td>
<td></td>
<td>330 ((100))</td>
</tr>
<tr>
<td>Roll Area, ft² (m^2)</td>
<td></td>
<td></td>
<td>4,950 ((460))</td>
</tr>
</tbody>
</table>

**NOTES:**
- \(^{(1)}\) Gradient of 0.1, normal load of 10,000 psf, water at 70° F \((20° C)\), between steel plates for 15 minutes.
- \(^{(2)}\) Roll widths and lengths have a tolerance of ±1%.

D. Resin
1. Resin shall be first quality, compounded polyethylene resin.
2. Natural resin (without carbon black) shall meet the following additional minimum requirements:
Table 2.1B: Raw Material Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method (1)</th>
<th>Testing Frequencies</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cm³)</td>
<td>ASTM D 1505</td>
<td>Once Per Resin Lot</td>
<td>&gt;0.94</td>
</tr>
<tr>
<td>Melt Flow Index (g/10 min)</td>
<td>ASTM D 1238</td>
<td>Once Per Resin Lot</td>
<td>≤1.0</td>
</tr>
</tbody>
</table>

2.2 MANUFACTURING QUALITY CONTROL

A. The geonet shall be manufactured in accordance with the Manufacturer’s Quality Control Plan submitted to and approved by the Contracting Officer.
B. The geonet shall be tested according to the test methods and frequencies listed below:

Table 2.2A: Manufacturing Quality Control Test Frequencies

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Test Method</th>
<th>Units</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td></td>
<td></td>
<td>Bi-Planar</td>
</tr>
<tr>
<td>Polymer Density</td>
<td>ASTM D 1505</td>
<td>g/cm³</td>
<td>Once Per Lot</td>
</tr>
<tr>
<td>Melt Flow Index</td>
<td>ASTM D 1238</td>
<td>g/10 min</td>
<td>Once Per Lot</td>
</tr>
<tr>
<td>Geonet Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>ASTM D 5199</td>
<td>mil</td>
<td>1/50,000 ft²</td>
</tr>
<tr>
<td>Carbon Black</td>
<td>ASTM D 4218</td>
<td>%</td>
<td>1/50,000 ft²</td>
</tr>
<tr>
<td>Tensile Strength, MD</td>
<td>ASTM D 4595</td>
<td>lbs/ ft</td>
<td>1/50,000 ft²</td>
</tr>
<tr>
<td>Transmissivity</td>
<td>ASTM D 4716-00</td>
<td>m²/sec</td>
<td>1/540,000 ft²</td>
</tr>
</tbody>
</table>

PART 3- EXECUTION

3.1 FAMILIARIZATION

A. Inspection
   1. Prior to implementing any of the work in the Section to be lined, the Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the Section may properly commence without adverse impact.
   2. If the Installer has any concerns regarding the installed work of other Sections, he shall notify the Contracting Officer.

3.2 MATERIAL PLACEMENT

A. The geonet roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified or shown in Drawings.
B. For long, steep slopes, special care should be taken so that only full-length rolls are used at the top of the slope.
C. In the presence of wind, all geonets shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until replaced with cover material.
D. In anchor trench at the top of the slopes, the geonet shall be
properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geonet.

E. In applying fill material, no equipment can drive directly across the geonet. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure.

F. The primary geomembrane liner shall be placed over the geonet in a manner that prevents damage to the geonet. Placement of the primary geomembrane liner shall proceed immediately following the placement and inspection of the geonet.

3.3 SEAMS AND OVERLAPS

A. Each component of the geonet will be secured to the like component at overlaps.

B. Geonet Components
   1. Adjacent edges along the length of the geonet roll shall be overlapped a minimum of 6” or as recommended by the Contracting Officer.
   2. The overlapped edges shall be joined by tying the geonet structure with cable ties. These ties shall be spaced every 5 feet along the roll length.
   3. Adjoining rolls across the roll width should be shingled down in the direction of the slope and joined together with cable ties spaced every foot along the roll width.

3.4 REPAIR

A. Prior to covering the deployed geonet, each roll shall be inspected for damage resulting from construction.

B. Any rips, tears or damaged areas on the deployed geonet shall be removed and patched. The patch shall be secured to the original geonet by tying every 6 inches with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the geonet shall be cut out and the two portions of the geonet shall be joined in accordance with Subsection 3.03.

END OF SECTION 31 38 26