Haley Griffith (adpce.ad)

Subject: RE: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

From: Paul Crawford <pcrawford@olsson.com>
Sent: Friday, October 3, 2025 3:56 PM
To: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Subject: Re: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

Richard,

Please see my responses to your questions in the attached document. Referenced specifications are also attached.

Paul

From: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Sent: Friday, October 3, 2025 12:42 PM
To: Paul Crawford <pcrawford@olsson.com>
Subject: RE: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

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Here is what we could discuss so when you call me my direct line (o861) you know wht my concerns wereh

1. They used Flexmat (not in the approved CQA)

2. pdf page 58 of 117 The moisture test is not in list of tests on page 57 and it seems to be a fail (8.67 < 12), also

the fluid loss seems to be a fail (11.2 < 18)

3. pdf page 59 of 117

The cover geotextile fails the grab strength (130.32 <160)

4. pdf page 63 of 117

where did they get the requirements since they don't seem to match the CQA (for example the tensile strength min is 50 not 45)

5. pdf page 76 of 117

The density analysis seems low (0.9205 < 932).

6. pdf page 77 of 117

The density seems low (0.937 < 0.94)

7. pdf page 81 of 117

your reference value of 38 should be 40 and 0.915 should be 0.94

8. pdf page 86 and 92 of 117

why don't we have the same number of tests of each side for extrusion tests

9. pdf page 101 of 117

The transmissivity reference value should e 9E-5, not 1E-4.

From: Paul Crawford <pcrawford@olsson.com>
Sent: Friday, October 3, 2025 12:14 PM
To: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Subject: Re: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

I will be out of town for business meetings week. If you send me your direct line, I will try to contact you when I have some time.

From: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Sent: Friday, October 3, 2025 10:59 AM
To: Paul Crawford <pcrawford@olsson.com>
Subject: RE: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

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How do you look next week?

From: Paul Crawford <pcrawford@olsson.com>
Sent: Wednesday, September 24, 2025 3:30 PM
To: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Subject: Re: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

I am available after 1 pm.

From: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Sent: Wednesday, September 24, 2025 2:00 PM
To: Paul Crawford <pcrawford@olsson.com>
Subject: RE: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

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How is tomorrow?

From: Paul Crawford <pcrawford@olsson.com>
Sent: Wednesday, September 24, 2025 11:01 AM
To: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Subject: Re: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

I have time between 3 and 5 open.

From: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Sent: Wednesday, September 24, 2025 10:45 AM
To: Paul Crawford <pcrawford@olsson.com>
Subject: RE: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

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How does your schedule look this afternoon?

From: Paul Crawford <pcrawford@olsson.com>
Sent: Monday, September 22, 2025 2:34 PM
To: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Subject: Re: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

Richard,

Sorry I missed your call. I just called you, but got your voicemail. I am in the office most of this week, so please call me at your convenience.

Paul

From: Richard Bennett (adpce.ad) <Richard.Bennett@arkansas.gov>
Sent: Wednesday, September 17, 2025 11:01 AM
To: Paul Crawford <pcrawford@olsson.com>
Subject: CCSWDA Legacy Landfill (Craighead County) - CQA report for let-downs

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Paul, I have looked at the CQA report and I have some questions. Are you free tomorrow to talk about it?

Richard Bennett | Engineer, PE

Regulated Waste Operations

Division of Environmental Quality | Office of Land Resources
5301 Northshore Drive | North Little Rock, AR 72118

t: 501.682.0861 | e:richard.bennett@arkansas.gov

ARKANSAS ENERGY & ENVIRONMENT

1. They used Flexmat (not in the approved CQA).

   Response: Flexamat is a concrete block mat material used as a replacement for the riprap stone typically used for the Legacy Landfill's stormwater letdowns. Similar to riprap used in the letdowns, this material does not need to be part of the CQA plan.

2. Page 58 - The moisture test is not in list of tests on page 57 and it seems to be a fail (8.67 < 12), also the fluid loss seems to be a fail (11.2 < 18).

   Response: The project specifications do not require a specific moisture content of the bentonite clay and no conformance test is required, however the manufacturer establishes a maximum limit of 12% for its product; therefore, the material meets their requirements.

   The fluid loss test, ASTM D5891, measures the amount of fluid lost (released from a bentonite sample); passing results for the bentonite are less than or equal to 18 ml. Therefore, this bentonite clay product met the specification. The table in the project specification for GCL material (page 5 of attached Section 02279), did not indicate that the 18 ml represents the MAXIMUM value.

3. Page 59 - The cover geotextile fails the grab strength (130.32 <160).

   Response: The results listed on this page of the report are for the geotextile used in the GCL, which is not the same geotextile product used for other purposes at the landfill which are specified in Section 02278 (attached). The geotextile used in the GCL does not have to meet the specifications listed in Section 02278.

   The test that determines the grab strength for the completed GCL is ASTM D6768, which is listed on page 5 of the attached specification Section 02279 and is a minimum of 45 lbs. The results presented in the manufacturers' reports are for information only; the project specification did not have a requirement for the geotextiles used in the production of GCL, only the completed GCL.

4. Page 63 - where did they get the requirements since they don't seem to match the CQA (for example the tensile strength min is 50 not 45).

   Response: The values listed as "Reference Value" are from the table in specification Section 02279 (page 5 of attached Section 02279).

5. Page 76 - The density analysis seems low (0.9205 < 932).

   Response: As listed in Table 02277-1 on page 10 of specification Section 02277 (attached), resin density must be a minimum of 0.915 g/cm^3, therefore, the resin met the requirements of the geomembrane material.

   Please note that the geomembrane material used for this project was linear-low density liner (LLDPE), which has a lower density than high density polyethylene (HDPE) liner.

6. Page 77 - the density seems low (0.937 < 0.94).

   Response: See response above; product meets project specification.

7. Page 81 - your reference value of 38 should be 40 and 0.915 should be 0.94

   Response: Please refer to Table 02277-1 of attached specification Section 02277. The "Reference Values" are from this table of the project specification.

8. Page 86 and 92 - why don't we have the same number of tests of each side for extrusion tests.

   Response: The technician recorded the five tests results as 3 "A" and 2 "B" samples; extrusion welds are only tested on one side. The results should be listed on one line as either all "A" sides or all "B" sides.

9. Page 101 - The transmissivity reference value should e 9E-5, not 1E-4.

   Response: The transmissivity listed on page 101 is for the completed geocomposite product. The specification for the completed geocomposite transmissivity is listed on page 6, section 2.03, E of the attached specification Section 02278. That value is a minimum of 1×10^{-4} m^2/sec. The product meets the specification.

SECTION 02277
GEOMEMBRANE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes furnishing and installing geomembrane as part of the final cover system construction.

1.02 REFERENCES

A. *Construction Quality Assurance Plan*, Craighead County Solid Waste Disposal Authority Legacy Class 1 Landfill (November 2015).

B. ASTM International:

1. ASTM D 638, Standard Test Method for Tensile Properties of Plastics.
2. ASTM D 746, Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
3. ASTM D 1004, Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.
4. ASTM D 1204, Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.
5. ASTM D 1238, Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastomer.
6. ASTM D 1505, Standard Test Method for Density of Plastics by the Density-Gradient Technique.
7. ASTM D 1603, Standard Test Method for Carbon Black Content in Olefin Plastics.
8. ASTM D 4218, Standard Test Method for Determination of Carbon Black Content in Polythene Compounds by the Muffle Furnace Technique.
9. ASTM D 4437, Standard Practice for Non-Destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
10. ASTM D 4833, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
11. ASTM D 5199, Standard Test Method for Measuring Nominal Thickness of Geosynthetics.
12. ASTM D 5397, Standard Test Method for Evaluation of Stress Crack

Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test.

13. ASTM D 5596, Standard Test Method for Microscopical Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.

14. ASTM D 6693, Standard Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes.

B. FTM Standard Number 101C, Method 2065, Puncture Resistance and Elongation Test (1/8 inch Radius Probe Method).

C. NSF International Standard 54-1993, "Flexible Membrane Liners".

D. Geosynthetic Research Institute (GRI) Test Method GM6, "Pressurized Air Channel Test for Dual Seamed Geomembranes".

1.03 SUBMITTALS

A. Submit the following to the CQA Firm, for review and approval, no later than fourteen calendar days prior to scheduled shipment of geomembrane:

1. Documentation of manufacturers' qualifications as specified in subsection 1.04.A of this section.

2. Manufacturer's quality control program manual, or descriptive documentation.

3. List of material properties and samples of the material.

4. Manufacturers' certification that the products to be furnished will comply with all product specifications in this section.

5. Documentation of installers' qualifications, as specified below and in subsection 1.04.E of this section.

a. Submit a list of at least ten completed facilities. For each installation, provide: name and type of facility; its location; the date of installation; name and telephone number of Owner, Design Engineer, Manufacturer, Fabricator, if applicable; name and telephone number of contact at the facility; thickness of geomembrane and surface area of the installed geomembrane; and type of seaming, patching, and tacking equipment.

b. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and all technicians to be assigned to this project.

B. Shop Drawings

1. Submit copies of shop drawings for approval as soon as possible after award of contract. Shop drawings shall show a proposed installation panel layout identifying seams and details. The layout diagram shall indicate the location of pre-assembled panels.

2. Placement of geomembrane will not be allowed to proceed until CQA Firm has received and approved the shop drawings. Any proposed deviation from these documents shall be submitted in writing to the CQA Firm a minimum of one or two working days prior to the scheduled start of geomembrane installation and will be accepted/rejected by the CQA Firm prior to start of installation activities.

C. Submit the following to the CQA Firm for review and approval no later than one calendar day prior to shipment of the products:

1. Origin and quality control certificates from the supplier of the resin used to manufacture the geomembrane, and certification that the properties of the resin meet the requirements for the project.

2. The manufacturers' quality control certifications, including results of source quality control testing of the products, as specified in subsection 2.01 of this section, to verify that the materials supplied for the project are in compliance with all product specifications in this section. The certifications shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers, and corresponding shipping information.

D. No geomembrane shall be deployed until the certifications and quality control certificates are submitted to and approved by the CQA Firm. Should geomembrane material be deployed prior to CQA Firm's approval, it shall be at sole risk of the Geomembrane Installer and Contractor, and if the material does not meet project specifications, it shall be removed from the project at the expense of the Contractor.

E. Additional Submittals (In-Progress and at Completion)

1. Quality Control test results (refer to subsection 2.01.A.4).

2. Manufacturer's warranty (refer to subsection 1.06).

3. Liner installation guarantee (refer to subsection 1.07).

4. Inventory of geomembrane rolls received onsite (refer to subsection 1.05.C).

5. Daily written acceptance of subgrade surface (refer to subsection 3.01.C).

6. Low temperature seaming procedures, if applicable (refer to

subsection 3.03.A).

7. Prequalification test seam samples (refer to subsection 3.05.A.3).

8. Non-destructive field seam test results (refer to subsection 3.05.B.1).

9. Destructive field seam test results (refer to subsection 3.05.C.5).

10. As-built survey drawing, as discussed in subsection 3.06.

1.04 QUALITY CONTROL/QUALITY ASSURANCE

A. Owner will retain the services of independent inspection and testing firms (Geosynthetics Quality Assurance Firm and Geosynthetics Quality Assurance Laboratory) to perform quality control and to check conformance of the materials and field seaming with the specifications, in accordance with Sections 01400 and 01410.

B. Codes and Standards: Perform all work in compliance with applicable requirements of governing authorities having jurisdiction.

C. Furnish all labor, materials, equipment, services, incidentals and other items necessary for the placement and installation of geomembrane as shown on the Contract Drawings and as specified herein.

D. Manufacturer's Qualifications: The manufacturer shall be a specialist in the manufacture of geomembrane of the type and shall have at least five years experience in the manufacture of such geomembrane. In addition, the geomembrane manufacturer shall have manufactured at least 10,000,000 square feet of the specified type of geomembrane during the last five years.

E. Installer's Qualifications

1. The Geomembrane Installer shall be the manufacturer or an approved contractor trained and licensed to install the manufacturer's geomembrane.

2. The Geomembrane Installer shall be a specialist in the installation of geomembranes of the type specified and shall have at least five years experience in the installation of such geomembranes. The geomembrane installer shall have installed at least 10,000,000 square feet of the specified type of geomembrane during the last five years.

3. Installation shall be performed under the constant direction of a single Field Installation Supervisor who shall remain on site and be in responsible charge, throughout the liner installation, for liner layout, seaming, patching, testing, repairs, and all other activities by the Installer. This Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 5,000,000 square feet of geomembrane of the type specified.

4. Seaming shall be performed under the direction of a Master Seamer (who may also be the Installation Supervisor or Crew Foreman) who has seamed a minimum of 5,000,000 square feet of geomembrane, of the type specified, using the same type of seaming apparatus specified in the current project. This Installation Supervisor and/or Master Seamer shall be present whenever seaming is performed.

5. All seaming, patching, other welding operations, and testing shall be performed by qualified technicians trained by the Geomembrane Installer.

1.05 DELIVERY, STORAGE AND HANDLING

A. Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label shall clearly state the manufacturer's name, product identification, lot number, material thickness, roll number, roll dimensions, and roll weight.

B. Geomembrane shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

C. Provide all labor and equipment required to assist the CQA Firm in the observation of materials delivered to the site. Generate, update and submit to the CQA Firm an inventory of geomembrane rolls received on-site from the manufacturer/distributor. The inventory shall include all the information appearing on the label of each roll.

D. Rolls shall be stored on a prepared surface (not wooden pallets) and shall not be stacked more than two rolls high.

1.06 MATERIAL WARRANTY

A. Membrane manufacturer shall warrant the membrane material against manufacturing defects and material degradation in the outdoor exposure for a period of twenty years from the date of installation.

B. The manufacturer shall provide new material to replace, on a prorated basis over the remaining life of the membrane, any material that fails from the above causes within the warranty period.

C. The manufacturer shall furnish the CQA Firm with a written warranty covering the requirements of this paragraph.

1.07 LINER INSTALLATION GUARANTEE

A. Guarantee the membrane installation against defects in installation and workmanship for one year commencing with the date of final acceptance.

B. The guarantee shall include the services of qualified service technicians and all material required for the repairs at no expense to the Owner.

1.08 GEOMEMBRANE PRE-CONSTRUCTION MEETING

A. A Geomembrane Pre-Construction Meeting shall be held at the site prior to installation of the geomembrane. As a minimum, the meeting shall be attended by the Geomembrane Installer, Project Manager, CQA Firm and/or his representative, and Contractor.

B. Topics for this meeting shall include:

1. Responsibilities of each party.
2. Lines of authority and communication.
3. Methods for documenting and reporting, and for distributing documents and reports.
4. Procedures for packaging and storing archive samples.
5. Review of time schedule for all installation and testing.
6. Review of panel layout and numbering systems for panels and seams.
7. Preparation of the as-built panel and seam drawing.

C. The meeting shall be documented by a person designated at the beginning of the meeting, and minutes shall be transmitted to all parties.

PART 2 PRODUCTS

2.01 GEOMEMBRANE

A. Shall be 40-mil low-density polyethylene (LLDPE) MicroSpike® geomembrane liner, as manufactured by Agru America, Inc., or approved equal.

B. The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The geomembrane shall be an unmodified seamless, LLDPE containing no plasticizers, fillers, chemical additives, or extenders. The geomembrane shall be smooth or textured on both sides and shall be supplied as a continuous sheet with no factory seams in rolls. The roll length and width shall be maximized to provide the largest manageable sheet for the fewest field seams.

C. The geomembrane material shall be produced free of holes, blisters, undispersed raw materials or any signs of contamination by foreign matter. Defects shall be

repaired by replacement and by using the extrudate welding technique in accordance with the manufacturer's recommendations.

D. The geomembrane shall be textured 40-mil LLDPE and shall meet or exceed the specifications listed in Table 02277-1.

2.02 BID ALTERNATES

A. Bid Alternate No. A1 shall be 50-mil LLDPE MicroDrain® geomembrane liner, as manufactured by Agru America, Inc., or approved equal.

B. The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The geomembrane shall be an unmodified seamless, LLDPE containing no plasticizers, fillers, chemical additives, or extenders. The geomembrane shall be smooth or textured on both sides and shall be supplied as a continuous sheet with no factory seams in rolls. The roll length and width shall be maximized to provide the largest manageable sheet for the fewest field seams.

C. The geomembrane material shall be produced free of holes, blisters, undispersed raw materials or any signs of contamination by foreign matter. Defects shall be repaired by replacement and by using the extrudate welding technique in accordance with the manufacturer's recommendations.

E. The geomembrane shall be textured 50-mil LLDPE and shall meet or exceed the specifications listed in Table 02277-1.

F. Bid Alternate No. A2 – Geotextile shall comply with Section 02278 2.02.

2.03 SOURCE QUALITY CONTROL

A. Manufacturing Quality Control

1. Every effort shall be made to minimize the number of lots of geomembrane needed to complete the work.

2. The following test methods shall be used by the manufacturer for the quality control/quality assurance of the geomembrane prior to delivery.

a. Density - ASTM D 1505

i. Quality control tests shall be performed in accordance with the test method for every 200,000 pounds of resin.

b. Carbon Black Content - ASTM D 1603 or ASTM D 4218

i. Quality control test shall be performed in accordance with the test method for every 20,000 pounds of resin.

c. Carbon Black Dispersion - ASTM D 5596

i. Quality control test shall be performed in accordance with the test method for every 45,000 pounds of resin.

d. Thickness - ASTM D 5199

i. Quality control test shall be performed in accordance with the test method for every 15,000 pounds of resin.

e. Tensile Properties - ASTM D 6693

i. Quality control test shall be performed in accordance with the test method for every 20,000 pounds of resin.

3. Results of environmental stress crack resistance tests (ASTM D 5397 - single point). At a minimum, test shall be performed once every resin lot (180,000 pounds).

4. Quality Control certificates, signed by a responsible party employed by the Manufacturer, shall be submitted to the CQA Firm prior to the installation of the geomembrane. The certificates shall include roll identification numbers, testing procedures, and results of quality control tests.

B. Conformance Testing

1. Prior to delivery of the geomembrane rolls to the project site, the Manufacturer shall send conformance samples of the liner material to the Geosynthetics Quality Assurance Laboratory for conformance testing. The samples of the material shall be obtained at a frequency of at least one sample per 100,000 square feet and at least one sample per lot of material shipped. If the samples cannot be obtained prior to shipment, a representative of the CQA Firm shall obtain the samples from the delivered rolls and forward the samples to the Geosynthetics Quality Assurance Laboratory for conformance testing.

2. Samples shall be taken across the entire width of the roll and shall not include the first three feet. Unless otherwise specified, samples shall be three feet long by the roll width. The machine direction shall be marked on the samples.

3. Conformance testing shall include the following tests, as a minimum:

a. Density or Specific Gravity - ASTM D 1505

b. Carbon Black Content - ASTM D 1603 or ASTM D 4218

c. Carbon Black Dispersion - ASTM D 5596

d. Thickness - ASTM D 5199

e. Tensile Properties (Yield Strength, Break Strength, Elongation at Yield and Elongation at Break) - ASTM D 6693

f. Tear Resistance - ASTM D 1004

TABLE 02277-1
GEOMEMBRANE MATERIAL SPECIFICATIONS

Property	Units	Test Method	Minimum Value
Thickness	mils	ASTM D 5994	38 (1)
Resin Density	g/cm^3	ASTM D 1505	0.915
Carbon Black Content	%	ASTM D 1603 or ASTM D 4218	2 - 3
Tensile Strength at Break	lbs/in	ASTM D 6693	60
Elongation at Break	%	ASTM D 6693	250
Tear Resistance	lbs	ASTM D 1004	22
Puncture Resistance	lbs	ASTM D 4833	44
Carbon Black Dispersion	Category	ASTM D 5596	1 or 2 (2)

Seam Properties	Units	Test Method	
Shear Strength	lbs/in	ASTM D 6392	60
Peel Strength – Wedge Weld (fusion)	lbs/in	ASTM D 6392	50
Peel Strength – Fillet Weld (extrusion)	lbs/in	ASTM D 6392	40

Notes:

1. Lowest Individual for 8 out of 10 valves = 36
   Lowest Individual for any of the 10 values = 34
2. Carbon Black Dispersion (only near spherical agglomerates) for 10 different views:
   9 in Categories 1 or 2 and 1 in Category 3 per GRI-GM13 in accordance with ASTM D 5596.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. The subgrade shall be prepared as specified in Section 02220. The subgrade shall be smooth and uniform, and free of all trash and debris, prior to installation of the geomembrane.

B. The Geomembrane Installer and the CQA Firm representative shall walk over the surface to be covered with geomembrane on each day's operations prior to placement of geomembrane.

C. The Geomembrane Installer shall provide to the CQA Firm written acceptance

daily for the surface to be covered by geomembrane in that day's operations. The surface shall be maintained as acceptable during geomembrane installation.

D. Subgrade damaged by construction equipment during the geomembrane deployment operation shall be repaired prior to placement of the geomembrane. The repairs shall be approved by the CQA Firm or its representative.

E. Subgrade damaged by erosion, rutting, or other means following geomembrane deployment shall be exposed and the damage repaired. Repairs shall be in accordance with Section 02220. The subgrade shall be reapproved in accordance with subsection 3.01.C of this section.

3.02 GEOMEMBRANE PLACEMENT

A. The geomembrane shall be installed as shown on the Drawings.

B. Panel Nomenclature

1. A field panel is defined as unit of geomembrane that is to be seamed in the field. A field panel is a roll or a portion of a roll cut in the field. The CQA Firm shall be responsible to ensure that each field panel is given an identification code (number or letter-number) consistent with the layout plan. This identification code shall be as simple and logical as possible and shall be agreed upon by the Project Manager, Installer and CQA Firm.

2. The CQA Firm shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

C. Panel Deployment Procedure

1. The CQA Firm shall review the panel deployment progress of the Installer and advise the Project Manager on changes in panel deployment. The CQA Firm shall also review the panel deployment for suitability to actual field condition such as issues relating to wind, rain, soil liner desiccation and other site-specific conditions. The CQA Firm shall verify that the condition of the underlying soil does not change detrimentally during installation. The CQA Firm shall record the identification code, location, and date of installation of each field panel.

D. Deployment Weather Conditions

1. Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment.

2. The normal acceptable weather conditions for seaming are as follows:

a. Ambient temperature between 32°F and 104°F.

b. Dry conditions (no precipitation or other excessive moisture).

c. No excessive winds.

3. Ambient temperature shall be measured and ambient conditions appraised by the CQA Firm in the area in which the panels are to be placed.

4. The CQA Firm shall inform the Project Manager of any weather-related problems that may not allow geomembrane placement to proceed. The Project Manager will determine if the installation is to be stopped or special procedures are to be used.

E. Method of Deployment

1. Before the geomembrane is handled on site, the CQA Firm shall verify that deployment equipment and method of deployment proposed by the Installer to be used on the site is adequate and does not pose risk of damage to the geomembrane or underlying subgrade. If vehicles are used which must operate on the geomembrane, driver shall proceed with caution during deployment of the geomembrane to prevent spinning of tires, sharp turns and quick stops. During handling, the CQA Firm shall observe and verify that the Installer's personnel handle the geomembrane with care.

2. The CQA Firm shall verify the following:

a. Equipment used does not damage the geomembrane or underlying subgrade by handling.

b. The prepared surface underlying the geomembrane is acceptable immediately prior to geomembrane placement.

c. Geosynthetic elements immediately underlying the geomembrane are clean and free of debris.

d. Personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities that could damage the geomembrane.

e. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting roll.

f. The method used to place the panels minimizes wrinkles especially differential wrinkles between adjacent panels.

g. Adequate temporary lading and/or anchoring (such as sand bags or tires), not likely to damage the geomembrane, are placed to prevent uplift by wind. In case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under the panels.

h. Direct contact with the geomembrane is minimized, and the

geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where repeated traffic use may be expected.

i. Liner has promptly been anchored in trench where applicable.

The CQA Firm shall notify the Project Manager if the above conditions are not fulfilled.

F. Damage and Defects

1. Upon delivery to the site, the CQA Firm shall conduct a surface observation of all rolls for defects and for damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected. The CQA Firm shall advise the Project Manager, in writing, or any rolls or portions of rolls that should be rejected and removed from the site because they have severe flaws, and/or minor repairable flaws.

2. The CQA Firm shall examine each panel, after placement and prior to seaming, for damage and/or defects. The CQA Firm shall advise the Project Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the CQA Firm. Repairs shall be made using procedures described in 3.06 of this section.

G. Writing on the Liner

1. To avoid confusion, the Installer and the CQA Firm shall each use different colored markers or other materials approved by the Project Manager that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane. The Installer shall use a white marker to write on the geomembrane while the CQA Firm shall use a yellow marker.

3.03 FIELD SEAMING

A. Seam Layout

1. Before installation begins, the Installer shall provide the Project Manager and the CQA Firm with a panel layout drawing. The drawing shall present all the proposed seams of the lining system at the facility. The CQA Firm shall review the panel layout drawing and verify that it is consistent with accepted industry standards.

2. In general, seams should be oriented parallel to the line of maximum slope. In corners and odd-shaped geometric locations, the number of seams should

be minimized. No horizontal seam should be less than five feet from the toe or crest of the slope, or from areas of potential stress concentrations, unless otherwise authorized by the Project Manager.

3. Horizontal seams shall be allowed only under the following conditions:

    a. Seams are offset in adjacent panels by one panel width.

    b. Seams are "shingled" downhill.

4. The CQA Firm shall use a seam numbering system compatible with the panel numbering system.

B. Accepted Seaming Methods

1. Approved processes for field seaming are fusion and extrusion welding. Proposed alternate processes shall be documented and submitted by the Installer to the Project Manager for approval. The Project Manager shall submit all documentation regarding seaming methods to be used to the CQA Firm for review.

2. Fusion Process

    a. The CQA Firm shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Project Manager.

    b. The CQA Firm shall also verify that:

        i. The Installer maintains onsite the number of spare operable seaming apparatus agreed at the pre-construction meeting.

        ii. Equipment used for seaming is not likely to damage the geomembrane.

        iii. The electrical generator is placed on a smooth base such that no damage occurs to the geomembrane and any fuel spills are promptly cleaned up. Fuel shall not be stored on the liner surface.

        iv. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs to the geomembrane.

        v. A movable protective layer is used as required by the Installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and to prevent debris from collecting around the pressure rollers.

        vi. In general, the geomembrane panels shall be aligned to have

an overlap of four to six inches for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

vii. No solvent or adhesive is used.

viii. The geomembrane is protected from damage in heavy traffic areas.

3. Extrusion Process

a. The CQA Firm shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Project Manager.

b. The CQA Firm shall also verify that:

i. The Installer maintains onsite the number of spare operable seaming apparatus agreed at the pre-construction meeting.

ii. Equipment used for seaming is not likely to damage the geomembrane.

iii. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.

iv. Clean and dry welding rods or extrudate pellets are used.

v. The electric generator is placed on a smooth base so no damage occurs to the geomembrane.

vi. Grinding is completed no more than one hour prior to seaming.

vii. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs to the geomembrane.

viii. The geomembrane is protected from damage in heavy traffic areas.

ix. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instances shall exposed grinding marks extend more than ¼-inch from the finished seamed area.

x. In general, the geomembrane panels are aligned to have a nominal overlap of three-inches for extrusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

xi. No solvent or adhesive is used.

xii. The procedure use to temporarily bond adjacent panels together does not damage the geomembrane; in particular,

the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged.

C. Seam Preparation

1. The CQA Firm shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the CQA Firm must ensure that the process is completed according to the Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane. The CQA Firm shall also verify that seams are aligned with the fewest number of wrinkles and "fishmouths."

D. Trial Seams

1. Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours, for each production seaming apparatus used that day. Trial seams shall be made under the same conditions as production seams.

2. The trial seam sample shall be at least five feet long by one foot wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section 3.03 B. Two specimens shall be cut from the sample with one-inch wide die. The specimens shall be cut by the Installer at locations selected randomly along the trial seam sample by the CQA Firm.

3. The specimens shall be tested in peel using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. They should not fail in the seam as described in Section 3.05 E. If a specimen fails, the entire trial seam operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. The CQA Firm shall observe all trial seam procedures.

4. The remainder of the successful trial seam sample shall be retained until project completion in the CQA Firm's archives for possible laboratory testing. Each sample shall be assigned a number and marked accordingly by the CQA Firm, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

5. If agreed upon by the Project Manager and the CQA Firm, and documented by the CQA Firm in his daily report, the remaining portion of the trial seam sample can be subjected to destructive testing as indicated in Section 3.05 F. If a trial seam sample fails a test conducted by the CQA Laboratory, then a destructive seam test sample shall be taken from each of the seams

completed by the seamer during the shift related the subject trial seam. These samples shall be forwarded to the CQA Laboratory and, if they fail the tests, the procedure indicated in Section 3.05 G shall apply. The conditions of this paragraph shall be considered satisfied for a given seam if a destructive seam test sample has already been taken.

E. General Seaming Procedures

1. During general seaming, the CQA Firm shall ensure the following:

a. "Fishmouths" or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut "fishmouths" or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of six-inches beyond the cut in all directions.

b. If seaming operations are carried out at night, adequate illumination shall be provided.

c. Seaming shall extend to the outside edge of panels placed in the anchor trench.

d. All cross-seam tees should be extrusion welded to a minimum distance of four-inches on each side of the tee.

e. A firm substance may be required to be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

The CQA Firm shall verify that the above seaming procedures or any other procedures agreed upon and indicated in the project Quality Assurance Plan are followed, and shall inform the Project Manager of any nonconformance.

F. Seaming Weather Conditions

1. Cold Weather Conditions

a. To ensure a quality installation, if seaming is conducted when the ambient temperature is below 32°F, the following conditions shall be met:

i. Geomembrane surface temperatures shall be determined by the CQA Firm at intervals of at least once per one hundred feet of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32°F.

ii. For fusion welding, preheating may be waived by the Project

Manager based on a recommendation from the CQA Firm, if the Installer demonstrates to the CQA Firm's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

iii. If preheating is required, the CQA Firm shall observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

iv. Care shall be taken to conform that wind chill does not adversely affect the pre-heat requirements specified for welding. It may be necessary to provide wind protection for the seam area.

v. All preheating devices shall be approved prior to use by the Project Manager.

vi. Sheet grinding may be performed before preheating, if applicable.

vii. Trial seaming, as described in Section 3.04 D, shall be conducted under the same ambient temperature conditions as the production seams. At the option of the CQA Firm, additional destructive tests may be required for any suspect areas.

3.04 NON-DESTRUCTIVE SEAM TESTING

A. Concept

The Installer shall nondestructively test all field seams over their full length using an air pressure test (for double fusion seams only), a vacuum test or other approved method. Air pressure testing and vacuum testing are described in Sections 3.04 B and 3.04 C, respectively. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantitative information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. For all seams, the CQA Firm shall:

1. Observe nondestructive testing procedures.
2. Record location, data, test unit number, name of tester, and outcome of all testing.
3. Inform the Installer and Project Manager of any required repairs.

B. Air Pressure Testing

1. Air pressure testing is applicable to double fusion welding which produces

a double seam with an enclosed space.

a. The equipment for air pressure testing shall consist of the following:

i. An air pump (manual or motor driven), equipped with pressure gauge and capable of generating and sustaining a pressure between 25 and 30 psi and mounted on a cushion to protect the geomembrane.

ii. A rubber hose with fittings and connections.

iii. A sharp hollow needle, or other pressure feed device, approved by Project Manager.

b. 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 air channel created by the fusion weld.

iii. Insert a protective cushion between the air pump and the geomembrane.

iv. Pressurize the air channel to a pressure of approximately 30 psi. Close valve, allow two minutes for pressure to stabilize, and sustain pressure for at least five minutes.

v. If loss of pressure exceeds the maximum permissible pressure differential as outlined in the project specifications or does not stabilize, locate faulty area and repair in accordance with Section 3.06 C.

vi. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seam the cut end of the air channel.

vii. Remove needle or other approved pressure feed device and seal the hole in the geomembrane.

C. Vacuum Testing

1. Vacuum testing is applicable to extrusion welding and to non-seam areas of the liner.

a. The equipment shall consist of the following:

i. A vacuum box assembly consisting of a rigid housing, a

transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.

ii. A pump assembly equipped with a pressure controller and pipe connections.

iii. A rubber pressure/vacuum hose with fittings and connections.

iv. A soapy solution (CQA Firm shall ensure solution makes bubbles when air is passed through. Windshield washer fluid shall be used as anti-freeze in cold weather.).

v. A bucket and wide paint brush, or other means of applying the soapy solution.

b. The following procedures shall be followed:

i. Wet a strip of geomembrane approximately twelve inches by forty-eight inches with the soapy solution.

ii. Place the box over the wetted area.

iii. Close the bleed valve and open the vacuum valve.

iv. Ensure that a leak-tight seal is created.

v. Energize the vacuum/venturi pump and reduce the applied pressure to approximately 5 psi (10 inches of Hg) gauge.

vi. For a minimum of ten seconds, apply vacuum with the box placed and maintaining a seal, examine the geomembrane through the viewing window for the presence of soap bubbles.

vii. If no bubble appears after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum three-inches overlap, and repeat the process.

viii. All areas where soap bubbles appear shall be marked and repaired in accordance with Section 3.06 C.

D. Test Failure Procedures

1. The Installer shall complete any required repairs in accordance with Section 3.06. For repairs, the CQA Firm shall:

a. Observe the repair and testing of the repair.

b. Mark on the geomembrane that the repair has been made.

c. Document the repair procedures and test results.

3.05 DESTRUCTIVE SEAM TESTING

A. Concept

1. The purpose of destructive tests is to evaluate seam strength. Destructive seam tests shall be performed at selected locations. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

B. Location and Frequency

1. The CQA Firm shall select where seam samples will be cut out for laboratory testing. The frequency and locations shall be established as follows:

   a. A minimum frequency of one (1) test location per 500 feet of production seam length performed by each welding machine. This frequency is to be determined as an average taken throughout the entire facility.

   b. Test locations shall be determined during seaming at the CQA Firm's discretion. Special consideration shall be given to locations where the potential for imperfect welding, such as overheating, contamination, offset welds exists.

2. The Installer shall not be informed in advance of the locations where the seam samples will be taken.

C. Sampling Procedures

1. Samples shall be cut by the Installer at locations chosen by the CQA Firm as the seaming progresses so that laboratory test results are available before the geomembrane is covered by another material. The CQA Firm shall:

   a. Observe sample cutting.

   b. Assign a number to each sample, and mark it accordingly.

   c. Record sample location on layout drawing.

   d. Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

2. All holes in the geomembrane resulting from destructive seam sampling shall be repaired in accordance with repair procedures described in Section 3.06 C immediately following receipt of successful test results. The

continuity of the new seams in the repaired area shall be tested according to Section 3.04 C.

D. Sample Dimensions

1. At each sampling location, two (2) types of samples shall be taken by the Installer. First, two specimens for field testing should be taken. Each of these samples shall be cut with a one-inch wide die, with the seam centered parallel to the width. The distance between these two samples shall be thirty inches. If both samples pass the field test described in Section 3.05 E, a sample for laboratory testing shall be taken.

2. The sample for laboratory testing shall be located between the samples for field testing. The sample for laboratory testing shall be twelve inches wide by thirty inches long with the seam centered lengthwise. The sample shall be cut into two parts and distributed as follows:

   a. One twelve inches wide by eighteen inches long portion for conformance testing by the CQA Laboratory.

   b. One twelve inches wide by twelve inches long portion to the CQA Firm.

3. Final determination of the sample sizes shall be made at the pre-construction meeting.

E. Field Testing

1. The two one-inch wide specimens mentioned in Section 3.03 D and Section 3.05 D shall be tested in the field using a tensiometer for peel adhesion and shall not fail according to the criteria in the project specifications. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. If the test passes in accordance with this section, the sample qualifies for testing in the laboratory. If it is non-conforming, the seam should be repaired in accordance with Section 3.05 G. Final judgment regarding seam acceptability, based on the conformance criteria provided in the project specifications, rests with the CQA Firm.

2. The CQA Firm shall witness all field tests and mark all samples and portions with their number. The CQA Firm shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description, and attach a copy to each sample portion.

F. Laboratory Testing (on or offsite)

1. Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the CQA Firm in a manner that will not damage the test sample. The sample shall be shipped as soon as possible to expedite laboratory testing. The CQA Firm will be responsible for storing the archive samples. Test samples shall be tested by the CQA Laboratory.

2. Testing shall include seam strength and peel adhesion (ASTM D 6392). The minimum acceptable values to be obtained in these tests are provided in Section 2.02 D. At least four specimens shall be tested successfully, each in both shear and peel. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear). A passing test shall meet the minimum acceptable values in at least four of the five specimens tested for each method.

3. The CQA Laboratory shall provide test results within twenty four hours of receiving the samples. The CQA Firm shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

G. Destructive Test Failure

1. When a sample fails a destructive test, whether that test is conducted by the CQA Laboratory or by field tensiometer, the Installer has two options:

   a. The Installer can repair the seam between any two passing destructive test locations.

   b. The Installer can trace the welding path to an intermediate location ten feet minimum from the point of the failed test in each direction and take a sample with a one-inch wide die for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is repaired between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be repaired.

2. All acceptable repaired seams shall be bound by two (2) locations from which samples passing laboratory destructive tests have been taken. Passing laboratory destructive tests of trial seam samples taken as indicated in Section 3.03 D may be used as a boundary for the failing seam. In cases exceeding 150 feet of repaired seam, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Repairs shall be made in accordance with Section 3.06.

3. The CQA Firm shall document all actions taken in conjunction with destructive test failures.

3.06 DEFECTS AND REPAIRS

A. Identification

1. All seams and non-seam areas of the geomembrane shall be examined by the CQA Firm for identification of defects, holes, blisters, undispersed raw materials, large wrinkles, and any sign of contamination by foreign matter. The geomembrane surface shall be cleaned by the Installer prior to examination if the CQA Firm determines that the amount of dust or mud inhibits examination.

B. Evaluation

1. Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in Section 3.04. Each location that fails the nondestructive testing shall be marked by the CQA Firm and repaired by the Installer. Work shall not proceed with any materials that will cover locations that have been repaired until successful nondestructive and/or laboratory tests are obtained.
2. When seaming of the geomembrane is completed, and prior to placing overlying materials, the CQA Firm shall indicate to the Project Manager any large wrinkles that should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation period, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. Wrinkles are considered to be large when the geomembrane can be folded over on to itself that is generally a wrinkle that extends twelve-inches from the subgrade. Seams produced while repairing wrinkles shall be nondestructively tested.
3. When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the CQA Firm to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

C. Repair Procedures

1. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Project Manager, Installer, Designer, and CQA Firm.

a. The repair procedures available include:

i. Patching: used to repair holes, tears, undispersed raw materials, and contamination by foreign matter.

ii. Spot welding: used to repair pinholes or other minor, localized flaws.

iii. Capping: used to repair large lengths of failed seams.

iv. Extrusion welding the flap: used to repair areas of inadequate fusion seams which have an exposed edge.

v. Removing bad seam and replacing with a strip of new material welded into place.

b. For any repair method, the following provisions shall be satisfied:

i. Surfaces of the geomembrane which are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair.

ii. All surfaces shall be clean and dry at the time of repair.

iii. All seaming equipment used in repairing procedures shall meet the requirements of the project Quality Assurance Plan.

iv. Patches or caps shall extend at least six-inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately three-inches.

D. Repair Verification

1. The CQA Firm shall observe all nondestructive testing of repairs and shall record the number of each repair, date and test outcome. Each repair shall be nondestructively tested using the methods described in Section 3.04 as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 150 consecutive feet long require destructive test sampling. Failed tests require that the repair shall be redone and retested until a passing test results.

3.07 GEOMEMBRANE PROTECTION

A. The quality assurance procedures indicated in this section are intended only to assure that the installation of adjacent materials does not damage the geomembrane. The quality assurance of the adjacent materials themselves are covered in separate Sections of this manual.

B. Soils

1. A copy of the project specifications prepared by the Designer for placement of soils shall be given to the CQA Firm by the Project Manager. The CQA Firm shall verify that these project specifications are consistent with geosynthetic state-of-practice such as:

   a. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32ºF nor above 104°F unless otherwise specified.

   b. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

   c. Equipment used for placing soil shall not be driven directly on the geomembrane.

   d. A minimum thickness of one-foot of soil is specified between a light dozer, ground pressure of 5 psi or lighter, and the geomembrane.

   e. In any areas traversed by construction traffic (any vehicles other than deployment equipment approved by the Project Manager) the soil layer shall have a minimum thickness of three feet. This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

2. The CQA Firm shall measure soil thickness and verify that the required thickness is present. The CQA Firm must also verify that final thickness is consistent with the design and verify that placement of the soil is done in such a manner that geomembrane damage is unlikely. The CQA Firm shall inform the Project Manager if the above conditions are not fulfilled.

B. Sumps and Appurtenances

1. A copy of the plans and project specifications prepared by the Designer for sumps and appurtenances shall be given by the Project Manager to the CQA Firm. The CQA Firm shall review these plans and verify that:

   a. Installation of the geomembrane in sump and appurtenant areas, and connection of geomembrane to sumps and appurtenances have been made according to project specifications.

   b. Extreme care is taken while welding around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas.

c. The geomembrane has not been visibly damaged while making connections to sumps and appurtenances.

d. A representative of the CQA Firm shall be present at all times when the Installer is welding geomembrane to appurtenant structures.

2. The CQA Firm shall inform the Project Manager in writing if the above conditions are not fulfilled.

C. Concrete

1. A copy of the project specifications prepared by the Designer for placement of concrete shall be given by the Project Manager to the CQA Firm. The CQA Firm shall verify that these specifications are consistent with the state-of-practice, including the use of geosynthetic layers between concrete and geomembrane. The CQA Firm shall verify that geosynthetic layers are placed between the concrete and the geomembrane according to design specifications. The CQA Firm will also verify that construction methods used are not likely to damage the geomembrane.

3.08 LINER ACCEPTANCE

A. The geomembrane liner will be accepted by the CQA Firm when:

1. The geomembrane is clean. Brooming and/or washing of the geomembrane surface shall be required if the amount of surface dust or mud inhibits inspection;

2. The entire installation is finished, or an agreed upon subsection of the installation is finished;

3. All documentation of installation is completed;

4. Verification of the adequacy of all field seams and repairs, and associated testing is complete;

5. An as-built drawing which documents the location of all panels, seams, tests, and other pertinent data is submitted to the CQA Firm; and

6. Daily field notes and sketches of the limits of each day's work are submitted to the CQA Firm.

B. If the accepted area of geomembrane has not been covered within a reasonable time, as determined by the CQA Firm, then the CQA Firm may re-inspect the area.

C. As-Built Survey

1. Contractor shall be responsible for performing an as-built survey of the geomembrane liner. Minimum survey requirements shall be as follows (in paragraphs 2 through 6).

2. The initial starting points for the overall installation shall be surveyed before the placement of subsequent layers of geosynthetics.

3. Destructive tests and liner penetrations shall be measured by a competent individual to the nearest one half foot from a known surveyed point.

4. Subsequent installation of geosynthetics shall not proceed until the CQA Firm has received and approved the geomembrane survey.

5. Contractor shall provide the Owner and CQA Firm with the as-built survey data.

6. Contractor shall prepare and provide the Owner and CQA Firm with a geomembrane liner as-built survey figure in adobe pdf format, and it shall be a minimum paper size of 24 inches by 36 inches. The figure shall display and label all geomembrane liner panels, destructive tests, repairs, liner penetrations, tie-ins to existing liner systems where applicable, and anchor trenches.

D. A passing test seam shall be an indicator of the adequacy of the seaming unit and seamer working under prevailing site conditions, but not necessarily an indicator of field seam adequacy. The test seam must also pass the laboratory tests under the destructive testing criteria. No soil shall be placed over geomembrane seams and patches until results of all destructive testing has been received and the liner has been accepted in writing by the CQA Firm.

E. For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test seam. More destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the CQA Firm and the same laboratory tests required of test seams shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test location shall be repaired with a cap-strip. The cap-strip shall be non-destructively tested and repaired, as required, until adequacy of the seams is achieved.

F. A passing non-destructive test of field seams and repairs shall be considered to indicate the adequacy of field seams and repairs.

3.09 ANCHOR TRENCH

A. Construct as specified in Section 02223.

3.10 DISPOSAL OF SCRAP MATERIALS

A. On completion of installation, the Geomembrane Installer shall dispose of all trash and scrap material in a location approved by the Owner, remove equipment used in connection with the work herein, and shall leave the premises in a neat, acceptable manner. No scrap material shall be allowed to remain on the geomembrane surface.

END OF SECTION

SECTION 02278
GEOTEXTILES AND GEOCOMPOSITES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes furnishing and installing geotextile and geocomposite as part of the final cover system and stormwater improvements construction.

1.02 REFERENCES

A. *Construction Quality Assurance Plan*, Craighead County Solid Waste Disposal Authority Legacy Class 1 Landfill (November 2015).

B. ASTM International:

1. ASTM D 413, Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate.
2. ASTM D 7005, Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.
3. ASTM F 904, Standard Test Method for Comparison of Bond Strength or Ply Adhesion of Similar Laminates Made From Flexible Materials.
4. ASTM D 1505, Standard Test Method for Density of Plastics by the Density-Gradient Technique.
5. ASTM D 1603, Standard Test Method for Carbon Black in Olefin Plastics.
6. ASTM D 3786, Standard Test Method for Bursting Strength of Textile Fabrics - Diaphragm Bursting Strength Tester Method.
7. ASTM D 4218, Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
8. ASTM D 4354, Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products for Testing.
9. ASTM D 4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
10. ASTM D 4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
11. ASTM D 4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
12. ASTM D 4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

13. ASTM D 4716, Standard Test Method for Determining the Transmissivity (In–Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic using a Constant Head.

14. ASTM D 4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.

15. ASTM D 4833, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

16. ASTM D 5034, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test).

17. ASTM D 5035, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method).

18. ASTM D 5199, Standard Test Method for Measuring Nominal Thickness of Geosynthetics.

19. ASTM D 5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

1.03 SUBMITTALS

A. Submit the following to the CQA Firm, for review and approval, no later than fourteen calendar days prior to scheduled shipment of geotextile and geocomposites:

1. Documentation of manufacturers' qualifications as specified in subsection 1.04.A of this Section.

2. Manufacturer's quality control program manual, or descriptive documentation.

3. List of material properties and samples of the material.

4. Manufacturers' certification that the products to be furnished will comply with all product specifications in this section.

5. Documentation of installers' qualifications, as specified in subsection 1.04.B of this section.

B. Submit the following to the CQA Firm for review and approval no later than 1 calendar day prior to shipment of the products:

1. The manufacturers' quality control certifications, including results of source quality control testing of the products, as specified in subsection 2.01 of this Section, to verify that the materials supplied for the project are in compliance with all product specifications in this Section. The certifications shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers, and corresponding shipping information.

C. No geotextile or geocomposite shall be deployed until the manufacturer's quality control certifications are submitted to and approved by the CQA Firm. Should the material be deployed prior to CQA Firm's approval, it shall be at sole risk of the Installer and Contractor, and if the material does not meet project specifications, it shall be removed from the project at the expense of the Contractor.

1.04 QUALITY ASSURANCE/QUALITY CONTROL

A. Manufacturer's Qualifications: The manufacturers shall be specialists in the manufacture of geotextile and/or geocomposite, as applicable. Geotextile and drainage geocomposite manufacturers shall have at least five years of experience in the manufacture of such material.

B. Installer's Qualifications

1. The Installer shall be the manufacturer or an approved contractor trained and licensed (if applicable) to install the manufacturer's product.

2. The Installer shall have at least five years of experience in the installation of the product. The Installer shall have installed at least 1,000,000 square feet of the product during the last five years or shall provide to the CQA Firm satisfactory evidence, through similar experience in the installation of other types of geosynthetics, that the product will be installed in a competent, professional manner.

C. Owner shall retain the services of independent inspection and testing firms (Geosynthetics Quality Assurance Firm and Geosynthetics QA Laboratory) to check conformance of the materials and installation with the specifications.

D. Codes and Standards: Perform all work in compliance with applicable requirements of governing authorities having jurisdiction.

1.05 DELIVERY, STORAGE AND HANDLING

A. Store material off of ground, rolled and covered to protect from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

B. Rolls shall be marked or tagged with the following information:

1. Manufacturer's name

2. Product identification

3. Lot number

4. Roll number

5. Roll dimensions

C. Replace defective or torn material at no cost to the Owner.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. The following test methods and frequencies shall be used, at a minimum, by the manufacturer for the quality assurance and control of the geotextiles and geocomposites prior to shipment of each product. Sampling and testing frequency shall conform to ASTM D 4354. Every effort shall be made to minimize the number of lots of each geosynthetic for use in the project.

B. Geotextile Manufacturing QC

1. Tests for Geotextiles:

a. Fabric Weight, ASTM D 5261

b. Grab Tensile Strength and Grab Tensile Elongation, ASTM D 4632

c. Puncture Strength, ASTM D 4833

d. Apparent Opening Size, ASTM D 4751

e. Flow Rate or Permittivity, ASTM D 4491

f. Trapezoid Tear Strength, ASTM D 4533

Frequency: Minimum of one test per 100,000 square feet and minimum of one test per lot.

C. Geocomposite (geotextile/geonet) Manufacturing QC

1. Tests for geonet portion of geocomposite:

a. Polymer Density, ASTM D 1505

b. Carbon Black Content, ASTM D 1603 or ASTM D 4218

c. Thickness, ASTM D 5199

d. Transmissivity, ASTM D 4716

e. Peak Tensile Strength, ASTM D 5034/5035

Frequency: Minimum of one test per 40,000 square feet and minimum of one test per lot for all except ASTM D 4716. For ASTM D 4716: minimum of one test per 100,000 square feet and minimum of one test per lot.

2. Tests for geotextile portion of geocomposite: Shall be as specified in Section 2.01 B above. Test shall be performed on material prior to adhering to geonet.

3. Tests for Finished Product: ASTM D 413, Geotextile Adhesion to Geonet. Frequency: Minimum of one test per 50,000 square feet and minimum of one test per lot.

D. For manufacturer's quality control testing of geotextiles and geocomposites, the sample average test results (weaker principle direction for mechanical tests) for a particular property for any individual roll tested within a lot designated as first quality shall meet or exceed the Minimum Average Roll Value indicated in the manufacturer's certification.

2.02 NONWOVEN GEOTEXTILE

A. The geotextile shall be a continuous filament polyester or polypropylene nonwoven needle-punched fabric. The fabric shall be inert to commonly encountered chemicals, biological degradation, hydrocarbons, acids, alkalines and mildew. The fabric shall be resistant to rot, ultraviolet light, insects and rodents.

B. The polyester or polypropylene filaments shall be formed into a stable network such that the filaments retain their relative position.

C. Geotextile shall conform to the following minimum requirements:

Fabric Property	**Unit**	**Test Method**	**Min. Avg. Roll Value[(1)]**
Fabric Weight	oz/sq yd	ASTM D 5261	6
Grab Strength	lbs	ASTM D 4632	160
Grab Elongation	%	ASTM D 4632	50
Trapezoid Tear Strength	lbs	ASTM D 4533	60
Puncture Resistance	lbs	ASTM D 4833	85
Permittivity Ψ	sec^{-1}	ASTM D 4491	1.3
AOS (largest opening size)	Sieve Size	ASTM D 4751	70

(1) Weakest Principal Direction

D. Minimum roll width shall be 12.5 ft. The roll length shall be maximized in order to minimize seams.

2.03 GEOCOMPOSITE

A. Shall be AGRU 250-mil Double Sided Geocomposite, as manufactured by Agru America, Inc., or approved equal. The fabric weight shall be six ounces.

B. Geocomposite shall be composed of a geonet core material with non–woven geotextile attached to both sides of the geonet (double-sided).

C. The geonet portion of the geocomposite shall be extruded as a continuous web comprised of two strands of polyethylene to form a 3-D structure to provide planar water flow, and conforming to the following minimum requirements:

Property	Unit	Test Method	Min. Avg. Roll Value
Thickness	mil	ASTM D 5199	200
Polymer Density	g/cm^3	ASTM D 1505	0.94
Peak Tensile Strength(1)	lb/in	ASTM D 5034/5035	32
Transmissivity(2)	m^2/s	ASTM D 4716	1×10^{-3}
Carbon Black Content	%	ASTM D 1603	2.0

(1) Machine direction.

(2) Measured using water @ 20° C with a gradient of one, between two steel plates, after one hour. Confining pressure 10,000 psf.

C. Geotextile used as part of the geocomposite shall conform to subsection 2.02.C of this Section.

D. The geocomposite shall be manufactured by heat bonding the geotextile continuously to the geonet on both sides. No burn through geotextiles shall be permitted. No glue or adhesive shall be permitted.

E. The finished geocomposite product shall conform to the following minimum requirements:

1. Transmissivity (ASTM D 4716): 1×10^{-4} m^2/sec

F. The bond between the geotextile and the geonet shall exhibit a minimum average peel strength of one pound per inch accordance with ASTM D 413, ASTM D 7005, or ASTM F 904.

G. Minimum roll width of the geocomposite shall be ten feet.

2.03 WOVEN GEOTEXTILE

A. Shall be Mirafi® 500X woven geotextile fabric, as manufactured by TenCate Geosynthetics, or approved equal.

B. The geotextile shall be a continuous filament polypropylene woven fabric. The fabric shall be inert to commonly encountered chemicals, biological degradation, hydrocarbons, acids, alkalines and mildew. The fabric shall be resistant to rot, ultraviolet light, insects and rodents

C. The polypropylene filaments shall be woven into a stable network such that the filaments retain their relative position.

E. Minimum roll width shall be 12.5 ft. The roll length shall be maximized in order to minimize seams.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Conformance Testing for Geotextile and Geocomposite Products:

1. Prior to delivery of the geotextile or geocomposite rolls to the project site, the Manufacturer shall send conformance samples of the liner material to the Geosynthetics Quality Assurance Laboratory for conformance testing. If the samples cannot be obtained prior to shipment, a representative of the CQA Firm shall obtain the samples from the delivered rolls and forward the samples to the Geosynthetics Quality Assurance Laboratory for conformance testing.

2. Samples shall be taken at the following frequency: a minimum of one test per 100,000 square feet and minimum of one test per lot.

3. Samples shall be taken across the entire width of the roll and shall not include the first three feet. Unless otherwise specified, samples shall be three feet long by the width of the roll.

4. Each sample shall be identified by manufacturer's name, product identification, lot number, roll dimensions, and roll number. The machine direction shall be noted on the samples with a waterproof marker.

5. As a minimum, the following tests shall be performed for the geotextile product (not part of geocomposite):

   a. Fabric Weight, ASTM D 5261

   b. Grab Strength and Grab Elongation, ASTM D 4632

   c. Puncture Resistance, ASTM D 4833

   d. Trapezoidal Tear, ASTM D 4533

   e. Permittivity, ASTM D 4491

f. Apparent Opening Size, ASTM D 4751

6. The following tests shall be performed for the finished geocomposite product:

a. Transmissivity, ASTM D 4716 (Water at 21°C, Gradient = 0.1 and pressure = 10,000 psf)

b. Geotextile Adhesion to Geonet, ASTM D 413, ASTM D 7005, or ASTM F 904

B. The CQA Firm shall ensure that the geotextiles and the geocomposite are installed according to manufacturer recommendations and the Contract Documents. The CQA Firm shall observe and document the installation activities.

3.02 PREPARATION

A. Surfaces to receive geotextile and geocomposites shall be smooth and free of litter, sharp protrusions, and large stones.

3.03 NONWOVEN GEOTEXTILE INSTALLATION

A. General

1. All geotextiles shall be weighted with sandbags or the equivalent when required. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

B. Installation

1. The geotextile shall be placed where shown on the Drawings, and placed in such a manner that placement of overlying material will not excessively stretch or tear the fabric.

2. Care shall be taken to keep the geotextile clean and free from debris prior to installation.

3. The geotextile shall be overlapped, and sewn along the entire length of joints in accordance with manufacturer's recommendations, and sufficient to prevent opening of seams by wind action.

4. In the presence of wind, the geotextile shall be weighted with sand bags until subsequent cover layer is installed.

5. On side slopes, the rolls shall be continuous for the full height of slope, without joints where feasible. End of roll seams shall be joined in accordance with the above Section 3.03 B3.

C. Seaming

1. Seaming shall be performed by sewing or other approved bonds. All seams

shall be continuously seamed. Spot seaming may only be considered as a measure against wind uplift. Overlaps shall be oriented in the direction of earth filling.

2. Vertical seams shall be “Prayer” seams.

3. Horizontal seams shall be “J” seams.

4. Any sewing shall be done using polymeric thread with chemical properties equal to or exceeding those of the geotextile.

3.04 GEOTEXTILE REPAIR

A. Holes or tears in the fabric shall be repaired as follows:

1. On steep slopes (steeper than 10 to 1): A fabric patch shall be sewn into place using a double sewn lock stitch (1/4 inch to 3/4 inch apart and no closer than 1 inch from any edge). Should any tear exceed 10% of the width of the roll, that roll shall be removed from the slope and replaced.

2. Flat Areas (flatter than 10 to 1): A fabric patch shall be spot-seamed in place with a minimum of 36 inches of overlap beyond the perimeter of the tear or damage in all directions.

B. Care shall be taken to remove any soil or other material, which may have penetrated through the torn geotextile.

3.05 GEOCOMPOSITE INSTALLATION

A. Care shall be taken to keep the geocomposite clean and free from debris prior to installation.

B. The top geotextile of the geocomposite shall be overlapped, and sewn along the entire length of joints in accordance with manufacturer's recommendations, and sufficient to prevent opening of seams by wind action.

C. In the presence of wind, the geocomposite shall be weighted with sand bags until subsequent cover layer is installed.

D. At locations where the geocomposite is damaged and soil penetrates the geocomposite material, it shall be removed and replaced with clean, unused geocomposite material.

E. Drainage Geocomposite Installation

1. Place perpendicular to contours (down slopes). Adjacent strips of the geonet material shall be overlapped two to four inches and shall be joined with brightly colored plastic ties approximately every five feet along the roll length.

2. Where adjacent panels of geocomposite overlap on side slopes of downdrain trenches and other depressions, the upgradient panel shall lap over the downgradient panel to prevent displacement or detachment of the geotextile from the geonet and clogging of the geonet during placement of cover soil.

3. On side slopes the rolls shall be continuous for the full height of slope, without joints where feasible. End of roll seams shall be joined in accordance with the above Section 3.05 B.

4. Care shall be taken to assure that underlying geomembrane is not damaged during placement of the geocomposite.

5. Geocomposite shall not be welded to geomembrane.

3.03 WOVEN GEOTEXTILE INSTALLATION

A. All geotextiles shall be weighted with sandbags or the equivalent when required. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

B. The geotextile shall be laid smooth on prepared subgrade parallel to the embankment. It shall be placed where shown on the Drawings, in such a manner that placement of overlying material will not excessively stretch or tear the fabric.

C. Woven geotextiles shall be overlapped a minimum of twelve inches.

D. No horizontal seams shall be allowed on slopes steeper than 10 horizontal to 1 vertical.

END OF SECTION

SECTION 02279
GEOSYNTHETIC CLAY LINER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes furnishing and installing geosynthetic clay liner (GCL) as part of the final cover system.

1.02 REFERENCES

A. ASTM International:

1. ASTM D 4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

2. ASTM D 4643, Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating.

3. ASTM D 5199, Standard Test Method for Measuring the Nominal Thickness of Geotextiles and Geomembranes.

4. ASTM D 5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

5. ASTM D 5321, Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear.

6. ASTM D 5887, Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.

7. ASTM D 5888, Standard Guide for Storage and Handling of Geosynthetic Clay Liners.

8. ASTM D 5889, Standard Practice for Quality Control of Geosynthetic Clay Liners.

9. ASTM D 5890, Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.

10. ASTM D 5891, Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.

11. ASTM D 5993, Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners.

12. ASTM D 6243, Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.

13. ASTM D 6496, Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.

14. ASTM D 6768, Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.

1.03 SUBMITTALS

A. Submit the following to the CQA Firm, for review and approval, no later than 14 calendar days prior to scheduled shipment of GCL:

1. Documentation of manufacturers' qualifications as specified in subsection 1.04.A of this Section.

2. Manufacturer's quality control program manual, or descriptive documentation.

3. List of material properties and samples of the material.

4. Manufacturers' certification that the products to be furnished will comply with all product specifications in this section.

5. Documentation of installers' qualifications, as specified in subsection 1.04.B of this Section.

B. Submit the following to the CQA Firm for review and approval no later than one calendar day prior to shipment of the products:

1. The manufacturers' quality control certifications, including results of source quality control testing of the products, as specified in subsection 2.01 of this Section, to verify that the materials supplied for the project are in compliance with all product specifications in this Section. The certifications shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers, and corresponding shipping information.

C. No GCL shall be deployed until the manufacturer's quality control certifications are submitted to and approved by the CQA Firm. Should the material be deployed prior to CQA Firm's approval, it shall be at sole risk of the Installer and Contractor, and if the material does not meet project specifications, it shall be removed from the project at the expense of the Contractor.

1.04 QUALITY ASSURANCE/QUALITY CONTROL

A. Manufacturer's Qualifications: The manufacturers shall be specialists in the manufacture of GCLs, as applicable. GCL manufacturers shall have at least two years experience in the manufacture of such material.

B. CQA Firm shall retain the services of independent inspection and testing firms (Geosynthetics Quality Assurance Firm and Geosynthetics Quality Assurance Laboratory) to check conformance of the materials and installation with the specifications.

1.05 DELIVERY, STORAGE AND HANDLING

A. Store material off of ground, rolled and covered to protect from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

B. Rolls shall be marked or tagged with the following information:

1. Manufacturer's name
2. Product identification
3. Lot number
4. Roll number
5. Roll dimensions

C. Replace defective or torn material at no cost to the Owner.

PART 2 PRODUCTS

2.01 GEOSYNTHETIC CLAY LINER

A. Shall be Bentomat® DN reinforced needle punched GCL, as manufactured CETCO Minerals Technologies Inc., or approved equal. Product shall be composed of a layer of natural sodium bentonite clay encapsulated between two geotextiles. Geotextiles shall be non-woven and the GCL shall be reinforced for stability.

2.02 SOURCE QUALITY CONTROL

A. The following test methods and frequencies shall be used, at a minimum, by the manufacturer for the quality assurance and control of the GCL prior to shipment of

each product. Sampling and testing frequency shall conform to ASTM D 5889. Every effort shall be made to minimize the number of lots of bentonite and geosynthetic for use in the project.

B. Geotextile Manufacturing QC (ASTM D 5889)

1. Geotextile Tests:

a. Mass per unit area (ASTM D 5261)
b. Grab Tensile Strength (ASTM D 4632)

Frequency: Minimum of one test per 200,000 square feet and minimum of one test per lot.

C. Bentonite Manufacturing QC (ASTM D 5889)

1. Bentonite Tests:

a. Free Swell (ASTM D 5890)
b. Fluid Loss (ASTM D 5891)
c. Bentonite Content

Frequency: Minimum of one test per 50,000 tonnes or minimum of one test per lot.

D. Finished GCL (ASTM D 5889)

1. GGL Tests:

a. Clay Mass Per Unit Area (ASTM D 5993)
b. Grab Tensile and Peel Strength (ASTM D 4632)
c. Index Flux (ASTM D 5887)
d. Hydraulic Conductivity (ASTM D 5887)

B. GCL shall conform to the following minimum requirements:

Property	Units	Test Method	Minimum Value
Bentonite Swell Index	ml	ASTM D 5890	24 mL / 2 g min
Bentonite Fluid Loss	ml	ASTM D 5891	18
Bentonite Mass/Area	lb/ft^2	ASTM D 5993	0.75
GCL Grab Strength	lbs	ASTM D 6768	45
GCL Peel Strength	lbs	ASTM D 6496	3.5
GCL Index Flux	$m^3/m^2/sec$	ASTM D 5887	1×10^{-8}
GCL Hydraulic Conductivity	cm/s	ASTM D 5887	5×10^{-9}
GCL Hydrated Internal Shear Strength	psf	ASTM D 5321 ASTM D 6243	500

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Conformance Testing for GCL:

1. Conformance testing samples shall be taken by the manufacturer prior to delivery or by the CQA Firm upon delivery of each product to the site.

2. Samples shall be taken at the following frequency: a minimum of one test per 100,000 square feet and minimum of one test per lot.

3. Samples shall be taken across the entire width of the roll and shall not include the first three feet. Unless otherwise specified, samples shall be three feet long by the roll width.

4. Each sample shall be identified by manufacturer's name, product identification, lot number, roll dimensions, and roll number. The machine direction shall be noted on the samples with a waterproof marker.

5. As a minimum, the following tests shall be performed for the GCL product:

   a. Bentonite Content (ASTM D 5993)
   b. Bentonite Swell Index (ASTM D 5890)
   c. Grab Strength (ASTM D 6768)
   d. Peel Strength (ASTM D 6496)
   e. Internal Shear Strength (ASTM D 5321 and D 6243)
   f. Hydraulic Conductivity (ASTM D 5887)

B. The CQA Firm shall ensure that the GCL is installed according to manufacturer recommendations and the Contract Documents. The CQA Firm shall observe and document the installation activities.

3.02 PREPARATION

A. Surfaces to receive GCL shall be smooth and free of litter, sharp protrusions, and large stones.

B. The Installer shall provide a subgrade acceptance form to the CQA inspector for each area that GCL is placed. The forms shall be signed by the Installer Supervisor and the CQA Monitor.

3.03 INSTALLATION

A. GCL rolls should be placed such that the geomembrane surface faces down.

B. Equipment that could damage the GCL shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.

C. Care must be taken to minimize the extent that the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL.

D. The GCL shall be placed so that seams are parallel to the direction of the slope.

E. All GCL panels should lie flat on the underlying surface, with no wrinkles or folds, especially at the exposed edges of the panels.

F. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, geomembrane, or a temporary waterproof cover. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material. The Engineer, CQA Firm or GCL supplier should be consulted for specific guidance if premature hydration occurs.

G. Place GCL in anchor trenches as shown on the Project Drawings.

3.04 SEAMING

A. Longitudinal GCL panels shall have an overlap of 6 inches. End-to-end panels shall have an overlap of 24 inches.

B. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.

C. Seams at the ends of panels shall be constructed such that they are "shingled" in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

D. Granular sodium bentonite shall be placed between GCL panels at end seams (longitudinal seams shall have the "self-healing" notches). The underlying edge of each panel shall be exposed and then a continuous bead of granular bentonite shall be applied along the edge of the panel within the overlap zone. The bentonite shall be applied at a minimum rate of one quarter pound per linear foot.

3.05 DAMAGE REPAIR

A. If the GCL is damaged (torn, punctured, or perforated) during installation, it shall be repaired prior to covering.

B. GCL damages may be repaired by placing a GCL patch over the damaged area. The GCL patch shall be obtained from a new GCL roll and shall be cut such that a minimum overlap of 12 inches is achieved around all of the damaged area.

C. Dry bentonite shall be placed around the damaged area prior to placement of the patch. The patch may be affixed with an adhesive to minimize displacement during cover placement.

3.06 COVER PLACEMENT

A. GCL shall be covered with geomembrane, geocomposite, and soil as shown on the Drawings.

B. Direct vehicular traffic with the GCL panels should be avoided. However, lightweight, low ground pressure vehicles may be used to facilitate the installation of the overlying soil. The CQA Engineer should be consulted prior to use of any machinery directly over the GCL material.

END OF SECTION

SECTION 02505
TERRACE ROAD

PART 1 GENERAL

1.01 SUMMARY

A. Section includes construction of gravel terrace roads including grading, testing, and aggregate surface course material.

B. Related Sections:

1. Section 02200 - Earthwork

1.02 REFERENCES

A. ASTM International.

1. ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
2. ASTM D 1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
3. ASTM D 2216, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
4. ASTM D 2487, Standard Practices for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
5. ASTM D 4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
6. ASTM D 6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

B. Arkansas Highway and Transportation Department (AHTD), *Standard Specifications for Highway Construction, 2014 Edition*.

1.03 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Submit written test reports of all specified tests showing conformance of the materials and constructed work with the specifications.

1.04 QUALITY ASSURANCE/QUALITY CONTROL

A. Owner will retain the services of an independent inspection and testing firm to determine conformance of earthwork materials and constructed work with the specifications, in accordance with Section 01400.

1.05 PROJECT CONDITIONS

A. Work shall be performed in a manner that does not disturb existing environmental monitoring wells or other site facilities not indicated to be removed within the construction limits.

B. Provide temporary controls as specified in Sections 01563 and 01565.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Proposed materials and source of supply shall be approved for use on this project by the Engineer as specified, prior to use of the materials in the construction.

2.02 GENERAL FILL

A. General Fill shall be as specified in Section 02200.

2.03 AGGREGATE SURFACE COURSE MATERIAL

A. Material shall meet Arkansas Highway Transportation Department (AHTD) Class 7 Stone specification. Material shall be crushed limestone.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare road subgrade to the lines, grades, and elevations as shown on the Drawings, and as specified in Section 02200, subsection 3.01.

B. Compact subgrade surface to 95% of Standard Proctor density or the satisfaction of the Engineer or Owner’s Representative.

3.02 PLACEMENT OF AGGREGATE SURFACE COURSE

A. Place aggregate surface course material to the dimensions shown on the Drawings.

B. Grade material to the lines and grades shown on the Drawings.

C. Compact and test material as specified in Section 02200.

END OF SECTION