



INTRODUCTION TO SAMPLE SPECIFICATION – GSE GUNDSEAL GCLS

The following specification guideline reflects current industry installation procedures and GSE GundSeal GCL quality control test procedures. This guideline is presented as a sample format to be used as a guide only in preparing project specific specification.

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Values designated by XXXX should be specified on a project specific basis.

SECTION XXXX

GEOMEMBRANE SUPPORTED GEOSYNTHETIC CLAY LINER

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Specifications and guidelines for MANUFACTURING and INSTALLING geosynthetic clay liners (GCL).

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM)
 1. ASTM D 638, "Standard Test method for Tensile Properties of Plastics."
 2. ASTM D 1004, "Test Method for Initial Tear Resistance of Plastic or Film Sheeting."
 3. ASTM D 2216, "Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-aggregate Mixtures."
 4. ASTM D 4354, "Standard Practice for Sampling of Geosynthetics for Testing."
 5. ASTM D 4643, "Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method."
 6. ASTM D 4759, "Standard of Practice for Determining the Specification Conformance of Geosynthetics."
 7. ASTM D 4833, "Standard Test Method for Index Puncture Resistance of
 8. Geotextiles, Geomembranes and Other Related Products."
 9. ASTM D 5084, "Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter."
 10. ASTM D 5199, "Measuring Nominal Thickness of Geotextiles and Geomembranes."
 11. ASTM D 5321, "Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method."
 12. ASTM D 5887, "Test Method for Measurement of Index Flux through Saturated Geosynthetic Clay Liner Using Flexible Wall Permeameter."
 13. ASTM D 5888, "Identification, Storage, and Handling of Geosynthetic Clay Liners."
 14. ASTM D 5889, "Standard Practice for Quality Control of Geosynthetic Clay Liners."
 15. ASTM D 5890, "Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners."
 16. ASTM D 5891, "Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners."
 17. ASTM D 5993, "Standard Test Method for Measuring Mass Per Unit Area of Geosynthetic Clay Liners."

18. ASTM D 6102, "Standard Guide for Installation of Geosynthetic Clay Liners."
 19. ASTM D 6243, "Standard Test Method for Determining the Coefficient of Soil and GCL or Geosynthetic and GCL Friction by the Direct Shear Method."
 20. ASTM D 6496, "Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners"
 21. ASTM D 6768, "Standard Test Method for Tensile Strength of Geosynthetic Clay Liners"
 22. ASTM E 96, "Standard Test Methods for Water Vapor Transmission of Materials"
- B. Section 4.0, Table 1. Properties and Test Frequencies for the geomembrane backings, loose bentonites, and finished geomembrane supported GCL.

1.03 DEFINITIONS

- A. Bentonite- Clay soils comprised primarily of sodium montmorillonite, characterized by high swelling potential and low hydraulic conductivity.
- B. Construction Quality Assurance (CQA) Officer- The professional representative of the CQA monitoring firm shall be responsible for implementation of the CQA plan.
- C. Geomembrane- An essentially impermeable membrane of high-density polyethylene (HDPE) containing 2 to 3 percent carbon black or titanium dioxide for ultraviolet light resistance.
- D. Geosynthetic Clay Liner (GCL)- Manufactured liner material consisting of a layer of granular bentonite affixed to a minimum average XXXX mil (XXXX mm) thick smooth/textured surface HDPE geomembrane liner by chemical adhesives.
- E. INSTALLER-Party responsible for GCL handling, transporting, storing, deploying, protecting, sampling, patching (damaged GCL) and temporary restraining (against wind and thermal/solar expansion) at the construction site.
- F. Lot- Group of consecutively numbered rolls from the same manufacturing line.
- G. MANUFACTURER- The party responsible for the production and quality of the GCL panels.
- H. Minimum Average Roll Value (MARV)- The minimum average value of a particular physical property of a material.
- I. OWNER- XXXX.
- J. Overlap- The width of material of a GCL panel in contact with an adjacent GCL panel. The distance measures perpendicular from the overlying edge of one panel

to the underlying edge of the other.

1.04 SUBMITTALS

- A. Product Data (MANUFACTURER): Submit the following to ENGINEER prior to shipping material to the site.
1. Geomembrane:
 - a. Certification stating that the geomembrane meets the product requirements Section 4.0, Table 1.
 - b. Copy of quality control tests performed by geomembrane supplier (if different from MANUFACTURER).
 - c. Copy of quality control tests performed by MANUFACTURER.
 2. Bentonite:
 - a. Certification stating that the bentonite meets the product requirements Section 4.0, Table 1.
 - b. Copy of quality control tests performed by bentonite supplier.
 - c. Copy of quality control tests performed by MANUFACTURER.
 3. GCL:
 - a. Certification stating that the GCL meets the product requirements Section 4.0, Table 1
 - b. Copy of quality control tests performed by MANUFACTURER.
 - c. Permeability testing on typical product.
 - d. Laboratory test data on typical product for Free Swell (ASTM D 5890).
- B. Qualifications (INSTALLER):
1. Submit the name of INSTALLER, resume of installation supervisor/field engineer to be assigned to the project, and list of projects completed by INSTALLER that involved geomembranes supported GCLs.
- C. Submit Quality Control Plan and Installation Procedures (MANUFACTURER) three (3) weeks prior to installation, including:
1. Copy of MANUFACTURER's quality control plan including list of quality control tests performed and typical testing frequencies.
 2. Recommended installation procedures.
 3. Panel layout drawing identifying panels and overlaps.

1.05 QUALIFICATIONS

- A. INSTALLER shall meet the following requirements:
1. Have experience in constructing lining/closure projects using GCL products.
 2. Have experience installing GCLs on at least 5 projects and have installed a minimum of 2,000,000 square feet (200,000 square meters) of GCL materials. Review of proposed installation procedures by the project engineer may relieve the Installer experience requirements on a project-specific basis.

1.06 QUALITY ASSURANCE

- A. The OWNER will engage the services of a CQA officer, and Construction Quality Assurance (CQA) Laboratory for monitoring the quality and installation of the GCL unless otherwise specified.
- B. The INSTALLER shall aid the CQA officer in the product sampling by providing personnel and equipment necessary to move, cut and protect GCL rolls and panels.

1.07 DELIVERY, STORAGE AND HANDLING

A. General: Conform to the MANUFACTURER's requirements and ASTM D5888 unless otherwise specified.

B. Delivery:

- 1. Deliver material to the site only after the CQA Officer accepts required submittals.
- 2. Material shall be covered with a waterproof, tightly-fitting, plastic covering resistant to ultraviolet degradation.
- 3. Ship less than one month prior to scheduled installation.
- 4. Each roll shall be marked with the following information:
 - a. manufacturer's name;
 - b. product identification;
 - c. lot or batch number;
 - d. roll number; and
 - e. roll dimensions

C. Storage:

- 1. Store rolls in space allocated by ENGINEER. Space should be at high ground level or elevated above ground surface.
- 2. Stack no more than 3 rolls high.
- 3. Protect rolls from precipitation, other sources of moisture, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.
- 4. Preserve integrity and readability of roll labels.

D. Handling:

- 1. Use appropriate handling equipment to MANUFACTURER's recommendations to load, move, or deploy GCL rolls.
- 2. Handling of rolls shall be done in a competent manner such that damage does not occur to the product or to its protective wrapping. Follow handling procedures outlined in ASTM D 5888.
- 3. Damage to protective covering due to mishandling or sampling must be repaired immediately. Repairs shall be such that the GCL roll is protected from moisture or other deleterious conditions.
- 4. INSTALLER is responsible for off-loading, storage, and transporting material from storage area to installation site.

PART 2 PRODUCTS

2.01 GENERAL PROPERTIES

- A. The GCL and its components shall exhibit properties and testing that meet or exceed the minimum average values shown in Section 4.0.
- B. The GCL shall conform to the requirements of Section XXXX-Testing Laboratory Services. No GCL shall be installed until the requirements of this Section and Section XXXX have been met, and approval of Engineer has been obtained.
- C. XXXX (minimum 6 in [150 mm])- overlap guideline shall be imprinted on one edge of the component of the GCL to be placed upward in the field as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

2.02 MATERIAL PROPERTIES

- A. Bentonite:
 - 1. Clay with a minimum average 80 percent sodium montmorillonite content
 - 2. Supplied in granular form
 - 3. Meet the requirements of Section 4.0, Table 1.
- B. Geomembrane:
 - 1. Minimum average XXXX mil (XXXX mm) smooth/textured (single/double sided texture), high density polyethylene (HDPE)
 - 2. Meet the requirements of Section 4.0, Table 1.
- C. GCL Product/GCL Rolls:
 - 1. Consist of bentonite affixed to a geomembrane by chemical adhesive or approved equal.
 - 2. Wrapped around structurally sound core that can support the weight of the GCL
 - 3. Meet all the requirements of Section 4.0, Table 3.

2.03 PACKING AND LABELING

- A. GCLs shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers and marked or tagged with the following information:
 - 1. MANUFACTURER's name
 - 2. product identification
 - 3. lot or batch number
 - 4. roll number
 - 5. roll dimensions

2.04 TRANSPORTATION

- A. Transportation of the GCL, to the site, shall be the responsibility of the MANUFACTURER. The MANUFACTURER shall be liable for all damages to the materials incurred prior to and during transportation to the site.

2.05 MANUFACTURING QUALITY CONTROL

- A. The GCL shall be subject to quality control and conformance testing to assure that the materials provided meet the minimum performance requirements. In most cases, sampling can be carried out on a sacrificial portions of the material. Consequently, repair of sampled locations should not be required.
 - 1. Quality Control Tests
 - a. MANUFACTURER shall verify that the geomembrane backing of the GCL meets the corresponding manufacturer's specification for that product.
 - b. MANUFACTURER shall verify the proper mass per unit area of bentonite has been added to the product.
 - c. All materials shall be tested in accordance with MANUFACTURER's quality control program. The MANUFACTURER shall perform testing. Samples not satisfying the MANUFACTURER's specifications shall result in the rejection of the applicable rolls. At the MANUFACTURER's discretion and expense, additional testing of individual rolls may be performed to more closely identify the non-complying rolls and/or to qualify individual rolls.
 - d. The MANUFACTURER shall certify the quality of the rolls. The quality control certificate shall include:
 - 1) roll number and identification
 - 2) sampling procedures
 - 3) results of all quality control tests, including a description of test methods used

PART 3 EXECUTION

3.01 MATERIAL INSTALLATION PROCEDURES

- A. General: The GCL installation should follow general guidelines provided by ASTM D 6102 unless otherwise specified.

3.02 PREPARATION OF FOUNDATION LAYER SURFACE

- A. The foundation soil layer surface shall be rolled to a smooth level surface, be free of stones typically greater than 0.50 inch (13 mm) diameter, and prepared as otherwise specified in Section XXXX -Earthwork.

3.03 GCL PLACEMENT

- A. Once the subgrade is accepted by the INSTALLER and approved by ENGINEER, GCL rolls shall be delivered to the working area in their original packaging. Immediately prior to deployment, the packaging shall be carefully removed without

damaging the GCL. The GCL shall be placed such that the geomembrane side of the GCL faces upward.

- B. Equipment used to deploy the GCL must be track or rubber tired with 40 psi (2 kPa) maximum ground pressure and is subject to approval by the ENGINEER. Equipment shall not cause rutting of the subgrade surface, shall not make sharp turns, and shall not be driven over the GCL, unless proper demonstration of GCL survivability and approval of ENGINEER can be obtained. Any damage to the subgrade or the GCL shall be the responsibility of the CONTRACTOR to replace or put back to the pre-installation conditions.
- C. Care shall be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the GCLs bentonite surface. A temporary geosynthetic subgrade covering slip sheet or rub sheet may be used, as necessary, to reduce friction damage during placement.
- D. Care shall be taken to not entrap objects or moisture beneath the GCL.
- E. The individual deployed rolls (panels) shall be placed so that overlapping edges are parallel to the direction of the slope. The panels shall be placed to ensure a minimum overlap of XXXX [typically 6 to 12 inches [150 to 300 mm], minimum 6 in (150 mm)] inches between panels.
- F. All GCL shall be placed and maintained flat on the underlying surface, with no wrinkles or folds, especially at the exposed edges of the panels.
- G. All exposed bentonite (product deployed bentonite side up) GCL panels shall be covered the same day as they are deployed with a geomembrane or equivalent.
- H. Product deployed geomembrane side up, bentonite side down, shall be ultimately covered with a minimum 12 inch (300 mm) thick layer of cover soil within one week of deployment.
- I. If the bentonite becomes hydrated before the cover soil layer is placed, it shall be tested and replaced, as necessary, to meet the specified maximum allowable moisture contents listed (generally $\leq 30\%$).
- J. On the side slopes, the GCL shall first be anchored securely, at the top of the slope, and then deployed down the slope in a controlled continuous manner. The GCL shall extend continuously from the top to the toe of the slope unless otherwise directed by the CQA Monitor.
- K. During windy conditions, the GCL edges shall be weighted down, if necessary, with a sufficient number of filled sandbags or underlying soil material to prevent damage to the GCL.
- L. The GCL material shall be cut with a sharp utility knife with a hook blade, or other approved device. Do not damage adjacent or underlying materials while cutting the GCL.

- M. The INSTALLER shall examine the GCL surface and remove any harmful foreign objects.
- N. Do not install GCL during periods of rain or in areas of ponded water or unusually moist soils.

3.04 GCL PLACEMENT

- A. The minimum dimension of the longitudinal overlap shall be 6 in (150 mm). End-of-roll overlapped seams shall be similarly constructed, with a minimum overlap of 12 in (300 mm) in all directions. Do not sew or use mechanical connections to hold the panels together. No additional granular bentonite is required for the GCL overlap areas.
- B. Seams at the ends of the 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.

3.05 DETAIL WORK

- A. The GCL shall be sealed around any penetrations and embedded structures in accordance with the Construction Drawings and the GCL MANUFACTURER's recommendations.

3.06 DEFECTS AND DAMAGE REPAIR

- A. If the GCL is defective or damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 in (300 mm) is achieved around all of the damaged area. The patch shall be placed with the bentonite side down. Adhesion tape may be used to hold the patch in place, while cover soil is being placed.

3.07 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

- A. General
 1. Field quality control is the responsibility of the INSTALLER. The INSTALLER must document that the installation proceeds in accordance with the requirements of this Specification Section.
 2. Field construction quality assurance (CQA) is the responsibility of the ENGINEER or OWNER's authorized representatives who shall be assisted by the INSTALLER. CQA consists of inspections, field-testing, laboratory testing, and record keeping.
- B. During Installation, the INSTALLER, along with the OWNER's authorized CQA representatives, shall inspect:
 1. Material Storage and Handling. Verify that the material is carefully unloaded and protected against ground moisture, rainfall, and other damaging conditions.

Material should be stored and handled in accordance with ASTM D 5888. GundSeal rolls should be stored in a well-drained area and covered with a tarpaulin or equivalent until the time of deployment.

2. Bentonite Moisture Content. Verify that the deployed product has a moisture content less than the maximum allowed by project specifications. If not otherwise specified, the bentonite coating of GundSeal should have a moisture content up to approximately 30% during installation and soil covering activities. The bentonite can be air-dried or sun-dried just prior to installation if necessary for localized areas of elevated bentonite moisture or hydration. Hydrated areas of bentonite should be covered with GundSeal patch or, alternately, removed.
3. Subgrade. Verify that the subgrade is relatively smooth and uniform. The subgrade should be free of any objects greater than 0.75 in (18 mm) unless otherwise specified. Final preparation of the subgrade surface may include smooth grading and/or smooth drum rolling the surface. Any surface objects greater than 0.75 in (18 mm) should be removed by scarifying the surface by manually removing unsuitable objects.

For isolated areas where the subgrade surface is questionable in regard to preventing damage to an overlying geosynthetic material, an alternative for reducing potential material damage may include deployment of a nonwoven needle-punched geotextile cushion between the subgrade and

4. Overlapped Seams. Verify that the material is installed and aligned with the proper overlap distance between panels. Minimum standard lengthwise overlap distance is 6 in (150 mm) and minimum standard widthwise overlap distance is 1 ft (300 mm). Overlap distance should be adjusted for site specific subgrade conditions.
5. Welded Geomembrane Seams. When the GundSeal geomembrane backing seams are fusion or extrusion welded, standard installation procedures, CQA practices, and seam testing procedures should be utilized as outlined in the *GSE GundSeal GCL Installation Quality Assurance Manual*.
6. Bentonite Prehydration. For applications that require prehydration of the bentonite at seam overlap areas and adjacent to structures, ensure the bentonite is adequately prehydrated. This should be accomplished by unfolding and exposing overlap seam areas and structures after the material is installed and subsequently liberally spraying the bentonite coating with tap water. In addition to spraying the bentonite coating of exposed contact areas, the structure surface and overlap geomembrane backing should also be prehydrated as the bentonite coating of the GCL. Compatibility of the bentonite with the hydrating liquid (other than tap water) should be verified with a bentonite free swell test (ASTM D 5890 or a simplified variation).
7. Repairs and Patches. Verify that the installed material is not damaged. For isolated areas where the geomembrane backing is punctured or torn, or where the bentonite coating has been dislodged during installation, the area should be patched. Patches

with GundSeal should be placed over the damaged area with the bentonite coating directly against the damaged area. Patches should extend a minimum 1 ft (300 mm) outward around the perimeter of the damaged area.

8. Dislodging of the Bentonite Coating. Verify that the GundSeal product is deployed and covered in a manner that does not scrape or dislodge the bentonite coating. To add protection to the bentonite layer of GundSeal, a thin spunbonded geotextile is attached to the bentonite surface to minimize the potential for dislodging and/or scraping the bentonite layer during installation. In areas where the bentonite coating has been scraped or dislodged, bentonite should be replaced by patching the effected area. For dislodged bentonite at roll edges resulting from material handling, the overlap distance should be increased to account for the bentonite loss.
9. Debris in the Overlapped Seams. Verify that no soil or other debris migrates into GundSeal overlap seams, or between GundSeal and the overlying geomembrane in an encapsulated mode.
10. Material Wrinkles and Fishmouths. Verify that the deployed GundSeal liner does not contain wrinkles or fishmouths. Wrinkles that cannot be pulled out manually should be (1) patched or (2) cut out and the area subsequently patched. Patches are made from the same base GundSeal material with the same specified overlap distances extending around the affected area(s).
11. Attachment to Structures. Verify the material is attached to structures (such as pipes, concrete foundations, and steel tanks) in accordance with the manufacturer's recommendations.
12. Material Anchorage at Slopes. Verify the material is properly anchored adjacent to slopes in accordance with the project design details.
13. Bentonite Protection Deployed Bentonite Side Up. When GundSeal is installed in an encapsulated mode (e.g., deployed with the bentonite side up with a separate overlying geomembrane), verify that all exposed bentonite is covered with the overlying geomembrane at the end of each workday. This will effectively protect the bentonite from premature hydration from stormwater run-off. The overlying geomembrane should be secured with ballast sandbags, or equivalent, around the perimeter of the GundSeal panel.
14. Bentonite Protection Deployed Bentonite Side Down. When GundSeal is installed bentonite side down (geomembrane side up), no additional daily covering is necessary to protect the bentonite. Caution should be taken, however, to protect the exposed perimeter panel edges from water pooling and subsequently flowing below the liner. This can be accomplished by confirming the perimeter of the deployed GundSeal material lies flat and in intimate contact with the subgrade soil by manually adjusting material. Alternately, temporary ballast, such as sandbags or soil, may be placed on top of the GundSeal material in areas to prevent material bridging over the subgrade.

- C. During soil cover operations, the INSTALLER, along with the OWNER's authorized CQA representatives, shall inspect:
1. Material Inspection. The OWNER's authorized CQA representatives shall inspect each panel of GCL placed before the GCL is covered.
 2. General Soil Cover Operations. Verify that GundSeal is covered with soil 1) in a timely manner, 2) in a careful manner, and 3) with adequate soil thickness ≥ 1 ft (300 mm).
 3. Subgrade Moisture Conditions. The following general recommendations are provided for moisture characteristics of soils, the intent being to cover the GundSeal before bentonite migration/displacement due to construction would cause concern:
 - a) *If the subgrade is relatively dry* (approaching the "wilting point" moisture content that makes it difficult for vegetation to grow), GundSeal should be covered within five days.
 - b) *If the subgrade is damp to moist* (approaching the "field capacity" moisture content that allows lush vegetation), GundSeal should be covered within three days.
 - c) *If the subgrade is moist to wet* (approaching saturation), it is advisable to cover GundSeal by the end of the following day.
 3. CQA Observation of Soil Cover Operations. Verify that the soil spreading operations are performed in accordance with the specifications and do not cause damage to the lining system.
 4. Contractor Observation of Soil Cover Operations. In the absence of CQA monitoring during soil cover operations, the contractor performing soil covering should provide a ground person in front of the spreading activities at all times. The primary responsibility of the ground person is (a) to establish and maintain adequate grade control of the cover soil layer, (b) to manually reduce or flatten wrinkles in the installed liner in advance of soil spreading, and (c) to identify and caution against any potential damage to the lining system.
- D. The INSTALLER and the OWNER's authorized CQA representatives shall verify proper installation procedures are followed for all other specified installation precautions.
- E. The INSTALLER shall aid the OWNER's authorized CQA representatives in collecting samples for testing as follows:
1. According to the requirements of the CQA Plan.
 2. Each conformance sample shall be a minimum of 2 feet (600 mm) long and run the entire width of the roll.
 3. Under direction of the OWNER's authorized CQA representatives, the INSTALLER shall mark the roll number and machine direction on each sample.
- F. Field Testing:
1. The OWNER's authorized CQA representatives shall conduct the following conformance tests:

- a. moisture content (ASTM D 2216)
- b. mass per unit area (ASTM D 5993)
2. Reported values shall be the average of 5 specimens taken from the sample.
3. If field testing passes (meets the requirements of Table 1), the remaining portion of the sample shall be sent to the CQA laboratory.

G. Laboratory Testing:

1. The following laboratory tests shall be conducted on samples passing field testing:
 - a. moisture content
 - b. mass per unit area (bentonite)
 - c. thickness (geomembrane only)
 - d. permeability (one test only on bentonite for the entire project) or fluid loss

H. In-place moisture content

1. Samples of installed GCL will be collected and tested for moisture content at the rate of 1 sample per 100,000 square feet (10,000 square meters).
2. This rate of sampling may be increased, at the discretion of the OWNER's authorized CQA representatives, to test samples after a precipitation event.
3. The OWNER's authorized CQA representatives will take samples before the full 12 inches (300 mm) of the final cover soil is placed on the GCL panel edges.
4. Samples shall be minimum of 4 in x 4 in (100 mm x 100 mm).
5. The average moisture content should be 25% (as delivered to the site) and less than 30% during installation, prior to completed placement of the final cover soil or panel sections will be unconditionally rejected and:
 - a. Bentonite portion allowed to sun dry or mechanically dried to the proper moisture content
 - b. New samples will be taken 50 feet (15 m) in either direction along the roll length (or at the end of the roll, if less than 50 feet (15 m) away).
 - c. The entire 100 foot (30 m) long-section of the roll between the new samples will be removed and replaced, following repair procedures (Section 3.06). The OWNER's authorized CQA representatives shall determine the width of the removed segment.

3.08 GCL ACCEPTANCE

- A. The INSTALLER shall retain ownership and responsibility of the GCL until the ENGINEER accepts it.
- B. The ENGINEER will accept the GCL installation after:
 1. All required documentation from the MANUFACTURER and INSTALLER has been received and accepted.
 2. Test reports verifying material properties have been received and accepted by the OWNER's authorized CQA representatives.
 3. The OWNER's authorized CQA representatives have completed final inspection and confirms that all noted defects have been repaired.

4.0 TABLE 1, Material Properties, test frequencies, and test methods for the bentonite, geomembrane backing and GundSeal composite geomembrane supported GCL.

GSE GundSeal Smooth HDPE

FINISHED GCL PROPERTIES	TEST METHOD	FREQUENCY	MINIMUM AVERAGE VALUE			
			SEG 015A000	SEG 040A000	SEG 060A000	SEG 080A000
Product Code			SEG 015A000	SEG 040A000	SEG 060A000	SEG 080A000
Bentonite Coating ⁽¹⁾ , lb/ft ² (kg/m ²)	ASTM D 5993	1/40,000 ft ² (1/4000 m ²)	≥ 0.75 (3.66)			
Effective Hydraulic Conductivity, m/s	ASTM D 5887/E 96	periodically	≤ 4 x 10 ⁻¹⁴			
Bentonite Moisture Content	ASTM D 2216	1/40,000 ft ² (1/4000 m ²)	25% Typical			
GEOMEMBRANE PROPERTIES⁽²⁾						
Thickness, (minimum average) mil (mm) Lowest individual reading (-10%)	ASTM D 5199	1/100,000 ft ² (1/10,000 m ²)	15 (0.40) 14 (0.34)	40 (1.00) 36 (0.91)	60 (1.50) 54 (1.35)	80 (2.00) 72 (1.80)
Density, g/cm ³	ASTM D 1505	1/200,000 ft ² (1/20,000 m ²)	0.94	0.94	0.94	0.94
Tensile Properties						
Tensile Break Strength ⁽³⁾ , lb/in (N/mm)	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	23 (4)	152 (27)	228 (40)	304 (53)
GCL Tensile Strength ⁽⁴⁾ , lb/in (N/mm)	ASTM D 6768	1/200,000 ft ² (1/20,000 m ²)	20 (3)	84 (15)	130 (23)	173 (30)
Elongation at Break, %	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	500	700	700	700
Puncture Resistance, lb (N)	ASTM D 4833	1/200,000 ft ² (1/20,000 m ²)	20 (89)	72 (320)	108 (480)	144 (640)
SODIUM BENTONITE PROPERTIES						
Hydraulic Flux: Bentonite, m ³ /m ² ·sec	ASTM D 5887	periodically	≤ 1 x 10 ⁻⁸			
Hydraulic Conductivity, m/s	ASTM D 5084	periodically	≤ 5 x 10 ⁻¹¹			
Free Swell, ml/2 g	ASTM D 5890	1/60,000 lb (1/30,000 kg)	≥ 24			
Fluid Loss, ml	ASTM D 5891	1/60,000 lb (1/30,000 kg)	≤ 18			
TYPICAL ROLL DIMENSIONS						
Roll Width ⁽⁵⁾ , ft (m)			17.5 (5.3)	17.5 (5.3)	17.5 (5.3)	17.5 (5.3)
Roll Length ⁽⁵⁾ , ft (m)			200 (61)	180 (54)	180 (54)	150 (45)
Roll Area, ft ² (m ²)			3,500 (325)	3,150 (286)	3,150 (286)	2,625 (244)
Roll Weight, lb (kg)			4,500 (2,050)	4,200 (1,900)	4,500 (2,050)	4,300 (1,950)

NOTES:

- ⁽¹⁾0% moisture content.
- ⁽²⁾See specific GSE HD geomembrane product data sheet for additional information.
- ⁽³⁾Type IV Dumbell, 2 in/min (51 mm/min), 2 in (51 mm) gage length.
- ⁽⁴⁾4 in (101 mm) wide sample, 12 in/min (305 mm/min). Values are representative of the geomembrane tensile yield strength.
- ⁽⁵⁾Roll lengths and widths have a tolerance of ± 1%.

GSE GundSeal Textured HDPE

FINISHED GCL PROPERTIES		TEST METHOD	FREQUENCY	MINIMUM AVERAGE VALUE			
Product Code				SEH 030A000	SEH 040A000	SEH 060A000	SEH 080A000
Bentonite Coating ⁽¹⁾ , lb/ft ² (kg/m ²)	ASTM D 5993	1/40,000 ft ² (1/4000 m ²)		≥ 0.75 (3.66)			
Effective Hydraulic Conductivity, m/s	ASTM D 5887/E 96	periodically		≤ 4 x 10 ⁻¹⁴			
Bentonite Moisture Content	ASTM D 2216	1/40,000 ft ² (1/4000 m ²)		25% Typical			
GEOMEMBRANE PROPERTIES ⁽²⁾							
Thickness, (minimum average) mil (mm)	ASTM D 5994	1/100,000 ft ² (1/10,000 m ²)	29 (0.73)	38 (0.96)	57 (1.45)	76 (1.93)	
Lowest individual for 8 out of 10 values			27 (0.69)	36 (0.91)	54 (1.37)	72 (1.83)	
Lowest individual for any of the 10 values			26 (0.66)	34 (0.86)	51 (1.30)	68 (1.73)	
Density, g/cm ³	ASTM D 1505	1/200,000 ft ² (1/20,000 m ²)	0.94	0.94	0.94	0.94	
Tensile Properties							
Tensile Break Strength ⁽³⁾ , lb/in (N/mm)	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	45 (8)	60 (11)	90 (16)	120 (21)	
GCL Tensile Strength ⁽⁴⁾ , lb/in (N/mm)	ASTM D 6768	1/200,000 ft ² (1/20,000 m ²)	63 (11)	84 (15)	130 (23)	173 (30)	
Elongation at Break, %	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	150	150	150	150	
Puncture Resistance, lb (N)	ASTM D 4833	1/200,000 ft ² (1/20,000 m ²)	45 (200)	60 (267)	90 (400)	120 (534)	
SODIUM BENTONITE PROPERTIES							
Hydraulic Flux: Bentonite, m ³ /m ² ·sec	ASTM D 5887	periodically		≤ 1 x 10 ⁻⁸			
Hydraulic Conductivity, m/s	ASTM D 5084	periodically		≤ 5 x 10 ⁻¹¹			
Free Swell, ml/2 g	ASTM D 5890	1/60,000 lb (1/30,000 kg)		≥ 24			
Fluid Loss, ml	ASTM D 5891	1/60,000 lb (1/30,000 kg)		≤ 18			
TYPICAL ROLL DIMENSIONS							
Roll Width ⁽⁵⁾ , ft (m)			17.5 (5.3)	17.5 (5.3)	17.5 (5.3)	17.5 (5.3)	
Roll Length ⁽⁵⁾ , ft (m)			180 (54)	170 (51)	170 (51)	150 (45)	
Roll Area, ft ² (m ²)			3,150 (286)	2,975 (276)	2,975 (276)	2,625 (244)	
Roll Weight, lb (kg)			4,100 (1,870)	4,300 (1,940)	4,600 (2,090)	4,400 (2,000)	

NOTES:

- ⁽¹⁾0% moisture content.
- ⁽²⁾See specific GSE HD Textured geomembrane product data sheet for additional information.
- ⁽³⁾Type IV Dumbell, 2 in/min (51 mm/min), 2 in (51 mm) gage length.
- ⁽⁴⁾4 in (101 mm) wide sample, 12 in/min (305 mm/min). Values are representative of the geomembrane tensile yield strength.
- ⁽⁵⁾Roll lengths and widths have a tolerance of ± 1%.

TABLE 2. TESTING FREQUENCIES AND PROPERTIES OF THE DELIVERED BENTONITE

PROPERTY	TEST METHOD ⁽¹⁾	FREQUENCY	MINIMUM AVERAGE VALUE
Free Swell	ASTM D 5890	1/60,000 lb (30,000 kg)	≥ 24 ml
Fluid Loss	ASTM D 5891	1/60,000 lb (30,000 kg)	≤ 18 ml
Hydraulic Flux: Bentonite Coating	ASTM D 5887	Periodically	≤ 1 x 10 ⁻¹⁰ m ³ /m ² ·sec
Hydraulic Conductivity	ASTM D 5084	Periodically	≤ 5 x 10 ⁻¹¹ m/s
Moisture Content	ASTM D 2216	1/60,000 lb (30,000 kg)	≤ 12%

NOTES:

- ⁽¹⁾GSE utilizes test equipment and procedures that enable effective and economical confirmation that the product will conform to specifications based on the noted procedures. Some test procedures have been modified for application to geosynthetics. All procedures and values are subject to change without prior notification.

TABLE 3. TESTING FREQUENCIES AND PROPERTIES FOR FINISHED GSE GUNDSEAL GCL PRODUCTS

PROPERTY	TEST METHOD ⁽¹⁾	FREQUENCY	MINIMUM AVERAGE VALUE
Bentonite Loading ⁽²⁾	ASTM D 5993	1/40,000 ft ² (40,000 m ²)	≥ 0.75 lb/ft ² (3.66 kg/m ²)
Moisture Content	ASTM D 2216	1/40,000 ft ² (40,000 m ²)	25% (typical)
Effective Hydraulic Conductivity	ASTM D 5887	Periodically	≤ 4 x 10 ⁻¹⁴ m/s

NOTES:

- ⁽¹⁾GSE utilizes test equipment and procedures that enable effective and economical confirmation that the product will conform to specifications based on the noted procedures. Some test procedures have been modified for application to geosynthetics. All procedures and values are subject to change without prior notification.
- ⁽²⁾Measured at 0% moisture content.

END OF SECTION