

CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

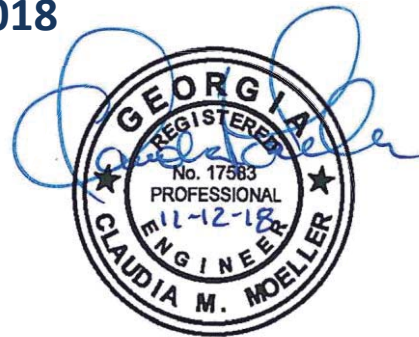
PLANT SCHERER COAL COMBUSTION RESIDUALS (CCR) LANDFILL MONROE COUNTY, GEORGIA

FOR



Georgia Power

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HHNT

HODGES, HARBIN,
NEWBERRY & TRIBBLE, INC.

Consulting Engineers

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1. GENERAL

This Construction Quality Assurance Plan (CQA Plan) instituted as part of the site's approved solid waste handling permit, provides the provide Construction Quality Assurance (CQA) and Construction Quality Control (CQC) standards, procedures, and minimum acceptance criteria for construction of the liners, leachate collection, and final cover systems at the Plant Scherer CCR Landfill.

This CQA Plan addresses those areas of construction pertaining to environmental protection including the necessary earthwork required for construction of the bottom liner and the leachate management and final cover systems. As each cell of the disposal facility is constructed or closed, Georgia Power Company (GPC) will submit a Construction Certification Report to the Georgia Environmental Protection Division (EPD) Solid Waste Program that includes a registered engineer's certification that the cell under consideration was constructed or closed within the limitations of and according to the approved permit.

Georgia Power will notify EPD of each major cell construction or closure event prior to initiating construction. CQA and CQC services will be provided by consulting engineering firms specializing in the inspection and testing of soils and geosynthetics. The services of the CQA/CQC firms required during construction and installation of all landfill components are described in this document.

The project team will consist of the following:

1. Design Engineer: Responsible for providing interpretations and clarifications of the technical specifications, reviewing and approving shop drawings, authorizing minor variations in the work from the requirements of the technical specifications, and rejecting defective work. The Design Engineer will be a registered professional engineer licensed in Georgia.
2. CQC Engineer: Responsible for CQC monitoring, testing and documentation for all field work performed during the construction of the facility. The Contractor will have the responsibility for providing for all field CQC testing by the CQC Engineer, or his representative, for all work performed. Reference to the CQA Engineer, for the purpose of this document, will include the CQA Engineer and his/her designated representatives.
3. CQA Engineer: Responsible for implementing the construction quality assurance requirements as stated in the project plans, technical specifications, this CQA Plan, and the project objectives; verifying basic data as reasonable and complete; outlining procedures to process data; developing statistical procedures for the analysis of test data; and preparing quality assurance memoranda and quality assurance reports. The CQA Engineer will report to Georgia Power. The CQA Engineer will be a registered professional engineer licensed in Georgia. Reference to the CQA Engineer, for the purpose of this document, will include the CQA Engineer and his/her designated representatives.

4. Engineering Technicians (Technicians): Responsible for field observations, testing and inspection. Technicians will be assigned to the project as deemed necessary by the CQC Engineer and will be under the supervision of the CQC Engineer. The CQC Engineer, technician or the CQC Engineer's representative will be on-site during all construction activities, except clearing and grubbing and initial grading activities. Initial evaluation of various soil types by CQC personnel during construction will be largely visual; therefore, all CQC personnel will be experienced with Visual-Manual Procedure for soil description and identification (ASTM D2488).
5. As-Built Surveyor: As required by specific sections of this CQA Plan, a registered professional land surveyor licensed in Georgia will perform the required as-built certification surveys on the components of the liner, leachate collection and/or final cover systems being constructed.

A separate set of technical specifications will be developed and included in the contract documents for cell construction and closure of the disposal facility. The technical specifications will provide the detailed processes, inspections and controls to ensure the structural fill, liner, leachate collection and final cover systems are constructed in accordance with this CQA Plan and the approved permit.

2. GRADING

A. GENERAL

The CQC Engineer will observe and document all earthwork grading (excavation/fill placement) activities and test the compaction of in-situ materials and structural fill. The CQA Engineer is responsible for certifying that the materials and construction of the earthworks are in accordance with the plans, technical specifications, and this CQA Plan.

B. EARTHWORKS MATERIALS

The technical specifications will list all requirements for the physical properties and construction procedures of all earthworks in accordance with this CQA Plan.

C. SUBGRADES

1. During construction, the CQC Engineer will test the subgrade soil materials. The CQC Engineer will monitor and document proofrolling of areas that are excavated to achieve grade. Soil placed to achieve the grades indicated on the plans will be tested by the CQC Engineer in accordance with the test methods and frequencies listed herein to verify that the compacted fill materials used by the Contractor comply with this CQA Plan. Areas of proofrolling or compacted fill that do not meet the requirements of this CQA Plan will be delineated and reported to the Contractor. The CQC Engineer will document that these areas are reworked by the Contractor and retested until passing results are achieved.
2. The CQC Engineer will monitor and document any subgrade that is damaged by excess moisture (causing softening), insufficient moisture (causing desiccation and shrinkage), or by freezing. When such conditions exist, the CQC Engineer will evaluate the suitability of the subgrade by one or more of the following methods:
 - a. Moisture / density testing;
 - b. Continuous visual inspection during proofrolling; and
 - c. Other test methods identified herein.
3. The CQC Engineer will inform the Contractor and will document when the Contractor repairs areas damaged as indicated above. The CQC Engineer will retest the repaired areas until passing results are achieved.

D. CONFORMANCE TESTING

1. The CQC Engineer will observe and test the structural fill soils to confirm that they are uniform and meet or exceed the requirements of this CQA Plan. For soil materials obtained from on-site or off-site borrow areas, the CQC Engineer will perform visual inspections and conformance tests prior to the materials being used to confirm that only soil materials meeting the requirements of this CQA Plan are transported to the site. For both on-site and off-site borrow areas containing non-uniform materials, the Contractor and the CQC Engineer will coordinate excavation, monitoring, and proper segregation of soil materials. The CQC Engineer will advise the Contractor and will document when the Contractor removes materials that fail to meet the requirements of this CQA Plan from the project site.
2. The CQC Engineer will observe soils for deleterious materials, (e.g., roots, stumps, rocks, and large objects). When necessary, the visual-manual procedure for the description and identification of soils will be conducted by the CQC Engineer in accordance with test method ASTM D2488.

E. TEST METHODS AND FREQUENCY

1. All soil testing performed to confirm compliance with the requirements of this CQA Plan will be conducted in accordance with this CQA Plan. The field-testing methods used to evaluate the suitability of soils during their placement will be performed by the CQC Engineer in accordance with current ASTM test procedures indicated in the table below.
2. Documentation and reporting of the test results will be the responsibility of the CQC Engineer.
3. The Standard Proctor Test (ASTM D698) will be used for the determination of moisture/density relationships unless otherwise indicated. In-place moisture/density testing will be by nuclear test method ASTM D6938, the sand cone test method ASTM D1556 or drive cylinder test method ASTM D2937. The sand cone test method ASTM D1556 or drive cylinder test method ASTM D2937 will be used to establish correlations of moisture and density in cases of uncertainty, and as a check of the nuclear surface moisture/density gauge calibration.
4. The minimum construction testing frequencies are presented in the table below. The frequency may be increased at the discretion of the CQA Engineer if variability of the materials is observed by the CQC Engineer. Sampling locations will be selected by the CQC Engineer. If necessary, the location of routine in-place density tests will be determined using a non-biased sampling approach.

Minimum Testing Requirements for Structural Fill	
Test	Frequency
Laboratory Moisture-Density/ASTM D698	1 test for each type of soil encountered
Liquid Limit, Plastic Limit, Plasticity Index/ASTM D4318	1 test for each type of soil encountered
Sieve Analysis/ASTM D422	1 test for each type of soil encountered
Field Density and Moisture Content/Sand Cone, ASTM D1556; Drive Cylinder, ASTM D2937; Nuclear, ASTM D6938	1 test per 1,000 c.y. of structural fill

5. A special testing frequency will be used at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem.

F. COMPACTION

The CQA Engineer will confirm that structural fill conforms to compaction requirements as follows:

Description	General Compaction	Top 12"
<ul style="list-style-type: none"> Landfill foundations, compacted fill and embankments; Sediment pond foundations and embankments; Road shoulders and embankments; Utilities under structures; and other areas 	95%	95%
Roadways	95%	98%

G. PROTECTION OF SUBGRADES AND COMPACTED FILL SURFACES

The CQC Engineer will monitor newly graded areas to verify the Contractor is protecting these areas from traffic and erosion until construction is complete.

3. LOW-PERMEABILITY SOIL LINER

A. GENERAL

The CQA Engineer will certify the low-permeability soil liner materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. MINIMUM REQUIREMENTS

The low-permeability soil liner will consist of cohesive soils from the borrow area or from existing stockpiles, synthetically improved soils, or imported cohesive soils meeting the remolded permeability criteria of $k \leq 1 \times 10^{-5}$ cm/sec.

C. PRE-CONSTRUCTION MATERIAL EVALUATION

1. All material to be used to construct the low-permeability soil liner will be sampled and tested by the CQC Engineer in advance of being placed. Such testing can be performed during excavation of the borrow area or from existing stockpiles.
2. The procedure for pre-construction testing during excavation and stockpiling of material to be used for low-permeability soil is outlined below:
 - a. The CQC Engineer will examine each load of soil either at the borrow source or the stockpile area. Soil that does not meet the technical specification for low-permeability soil liner material will be rejected or routed to separate stockpiles.
 - b. The following tests will be performed at the frequencies listed in the CCR Landfill Soil Liner Construction Quality Assurance Requirements Table on page 9, prior to placement of any low-permeability soil liner material:
 - i. Method for Particle - Size Analysis of Soils, ASTM D422 (Mechanical Sieve Method Only),
 - ii. Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D2216,
 - iii. Test Method for Liquid Limit, and Plasticity Index of Soils, ASTM D4318,
 - iv. Moisture-Density Curve (ASTM D698), and
 - v. Remolded permeability testing (ASTM D5084 - Measurement of Permeability of Saturated Porous Materials using a Flexible Wall Permeameter).
3. Reports for low-permeability soil liner will be prepared by the CQC Engineer and will include:

- a. Summary of laboratory test data, and
- b. A summary of construction, sampling and testing method, and recommendations for compaction moisture content to achieve the required permeability.

D. SUBGRADE

1. The CQA Engineer will verify that the low-permeability soil liner subgrade is constructed in accordance with the technical specifications.
2. The CQC Engineer will document that the subgrade is scarified to a depth of 6 inches and compacted to a density of 95% or more as determined by the Standard Proctor Test, ASTM D-698.
3. The CQC Engineer will document that the subgrade is reasonably free of large rocks, large roots, stumps, and other debris.

E. TEST PAD CONSTRUCTION

1. The CQC Engineer will document the construction of a test pad prior to, or coinciding with, the beginning of construction of the low-permeability soil liner.
2. The CQC Engineer will sample and test soil samples obtained from the constructed test pad to confirm that the material and the Contractors' placement and compaction methods used can consistently produce a low-permeability soil liner layer that meets the requirements of this CQA Plan.
3. The CQC Engineer will confirm that the Contractor uses the same placement and compaction methods, equipment, and material to construct the remaining low-permeability soil liner.

F. CONSTRUCTION

1. Only soil from a source previously sampled, tested and confirmed to meet the requirements of this CQA Plan will be used to construct the low-permeability soil liner. The CQC Engineer will notify the Contractor when material does not meet the requirements of this CQA Plan and will document that this material will not be used for low-permeability soil liner construction.
2. The CQC Engineer will complete all required field density and moisture content tests before the overlying lift of low-permeability soil liner is placed.

3. The CQC Engineer will observe and document that the Contractor completes all surface preparation (e.g., wetting, drying, scarification, etc.) before placement of subsequent lifts.
4. The CQC Engineer will observe and document that loose lift thicknesses do not exceed 10 inches (unless otherwise required in this CQA Plan) for a final 6-inch compacted lift thickness.
5. The CQC Engineer will check each lift visually for the presence of rocks, debris, plant materials, and other foreign material as well as for particle sizes or clods that exceed the requirements in this CQA Plan. The CQC Engineer will inform the Contractor if such materials are found and will document their removal.
6. The CQC Engineer will observe and document that the exposed surface of the low-permeability soil liner is rolled with a smooth drum roller or equivalent at the end of each workday or when required to protect the compacted soil liner from adverse weather conditions.
7. The CQC Engineer will observe and document that the exposed surface of the low-permeability soil liner is reasonably free of all rock, rock fragments, or loose materials. The CQC Engineer will observe and document that rock or other materials protruding more than ¼ -inch and other loose materials are removed, all cracks or voids filled, and the surface made uniform.
8. The CQC Engineer will observe and document that the surface on which the geosynthetics is to be placed is maintained in a firm, clean, dry, and smooth condition before and during the geosynthetics installation. Additionally, the CQC Engineer will inform the Contractor when desiccation cracking is excessive and will document that all desiccation cracks are repaired as required by this CQA Plan.
9. The CQC Engineer will inspect the low-permeability soil liner and certify that it is in accordance with this CQA Plan and approved permit drawings. Placement of geosynthetics on any portion of the low-permeability soil liner surface by the geosynthetics installer will constitute his acceptance of the surface.
10. The CQC Engineer will document that the required as-built certification surveys are performed on the low-permeability soil liner prior to installing the overlying geosynthetics materials.

G. SAMPLING AND TESTING

1. Construction Quality Control field and laboratory testing will meet the minimum requirements indicated in the Table below.

CCR Landfill			
Low-Permeability Soil Liner Construction Quality Assurance Requirements			
Item	Testing	Minimum Frequency	Minimum Criteria
Low-Permeability Soil Liner Material Borrow Source	Grain Size (ASTM D422, Sieves Only)	1,000 yd ³	< 1.0 inch (99%) < ¼ inch (Top 6") (99% of all Tests) 30% min passing the No. 200 sieve
	Moisture Content (ASTM D2216)	1,000 yd ³	
	Atterberg Limits (ASTM D4318)	5,000 yd ³	
	Moisture-Density Curve (ASTM D698)	5,000 yd ³ and All Changes in Material	
	Permeability of Remolded Samples (ASTM D5084)	10,000 yd ³	$k \leq 1 \times 10^{-5}$ cm/sec
Low-Permeability Soil Liner During Construction	Density and Moisture-Nuclear, Sand Cone or Drive Tube (ASTM D-6938, D-1556 or D-2937)	1 Test/10,000 sf/lift and 1 Test/Lift/200 lf of Sidewall	≥ 95% Standard Proctor @ moisture content per test fill (but no less than 1% below OMC)
Laboratory Testing on Undisturbed Samples of the Constructed Low-permeability soil liner	Permeability (ASTM D5084)	1 test/40,000 sf/lift and 1 test/lift/800 lf of sidewall	$k \leq 1 \times 10^{-5}$ cm/sec
	Dry Density (ASTM D-5084)		≥ 95% Standard Proctor
	Moisture Content (ASTM D-2216)		

2. The CQC Engineer will randomly determine the location of each test. All test holes will be patched with a mixture of low permeability soil and sodium bentonite pellets hydrated and compacted in the holes.
3. The CQC Engineer will follow this procedure in the event of a density or permeability test failure. If the density does not meet minimum requirements of this CQA Plan, recompaction of the failed area (minimum 100 feet x 100 feet) will be performed and retested until the area meets or exceeds requirements outlined in this CQA Plan. If a permeability sample fails to meet the minimum permeability requirements outlined in

this CQA Plan, the area of failing permeability (minimum 40,000 sf) will be reconstructed. Optionally, at least four (4) replicate samples will be obtained in the immediate vicinity of the failed test. Should the replicate samples confirm the failure of the soil to meet the requirements listed in this CQA Plan, the area of failure will be localized according to the results of the replicate samples and reconstructed. All areas of reconstruction will be retested as outlined in this CQA Plan.

4. The CQC Engineer will screen material obtained from a one square foot section of low-permeability soil liner for every 20,000 square feet of liner constructed and confirm that the following particle size criteria is met:

Lower 18 inches Soil Liner	
Percentage of Material Passing (By Weight)	Screen Size
99% (All Test)	1"
99.5% (Avg. of All Test)	1 ½"
99.8% (Avg. of All Test)	2"

Upper 6 inches Soil Liner	
Percentage of Material Passing (By Weight)	Screen Size
99% (All Test)	¼"
99.5% (Avg. of All Test)	½"
100% (Avg. of All Test)	1"

Should any sample fail the passing (99% passing 1/4 inches for the upper six (6") inches and 99% passing 1 inch for the lower 18"), then four (4) additional test areas within the 20,000 square foot test area will be selected by the CQC Engineer and tested in like manner. If the four (4) areas pass, then all test areas will be repaired, and the 20,000 square foot area accepted. If any one of the four (4) areas fails, then the 20,000 square foot area will be reworked and retested. Rocks or roots remaining on or protruding through the surface will be removed and the surface repaired.

4. REINFORCED GEOSYNTHETIC CLAY LINER (GCL)

A. GENERAL

The CQA Engineer will certify that the material and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. GCL MATERIAL PRE-DEPLOYMENT REVIEW

1. GCL PRODUCT DATA

The CQA Engineer will review the Contractor's submittals for conformance with this CQA Plan and/or the latest version of GRI-GCL3 – Standard Technical specification for “*Test Methods, Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)*”, whichever is more stringent, unless otherwise directed by the Design Engineer.

The CQA Engineer will verify that the GCL to be used is a reinforced Coal-Ash Resistant (CAR) product. Additionally, the CQA Engineer will verify that the GCL consists of a bentonite mat manufactured with a non-woven geotextile on each side, unless otherwise approved by the Design Engineer.

2. SHIPMENT AND STORAGE

The CQC Engineer will verify that all GCL delivered to the project site is stored in a dry area protected from precipitation and direct sunlight. The GCL will be individually wrapped in protective plastic and placed on pallets to assure drainage beneath the rolls. The GCL rolls will be completely covered with polyethylene, maintained in good condition, until the GCL is deployed. GCL which has become wet (water content > 40%) prior to deployment will be rejected.

3. QUALITY CONTROL CERTIFICATES

The CQC Engineer will:

- a. Verify that the manufacturer's quality control (QC) certificates have been provided at the specified frequency and that each certificate identified the rolls related to it, and
- b. Review the manufacturer's QC certificates and verify that the certified properties meet the requirements in this CQA Plan or GRI-GCL3, whichever is more stringent.

4. GCL CONFORMANCE TESTS

The CQC Engineer will perform the Conformance Tests in accordance with and at the frequencies listed below. The sampling will be performed at the GCL manufacturing plant and the test results reviewed and accepted prior to delivery of the GCL to the project site.

Required GCL Properties ¹				
Property	Test Method	Units	Value	Test Frequency
Permeability (or by Index Flux)	ASTM D5084 ² (ASTM 5887 APPX 2)	cm/sec	$k \leq 5.0 \times 10^{-9}$	Per GRI-GCL3
Internal Friction Test	ASTM D6243	Degrees	$\geq 23^{2,4,5}$	1 per 10 acres (min. 2 per project) per interface
Interface Friction Test	ASTM D6243	Degrees	$\geq 23^{3,4,5}$	

Notes:

- (1) In addition to the requirements listed in this table, the manufactured GCL will be tested and meet the requirements set forth in the latest version of the Geosynthetic Research Institute's technical specification GCL-3 (GRI-GCL3) for reinforced GCLs.
- (2) Degree is shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer.
- (3) Degree is shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer.
- (4) Tested at a normal pressure defined by the Design Engineer and held for 24 hours hydrated.
- (5) Based on peak strength values.

Samples will be taken across the entire width of the roll and will not include the first lineal 3 feet. Unless otherwise specified, samples will be 3 feet long by the roll width. The CQC Engineer will mark the machine direction on the samples with an arrow. All test results must be available at the site prior to the deployment of all GCL. The CQC Engineer will examine all results from laboratory testing.

5. Material Conformance Test Failure:

The following procedure will apply whenever a sample fails a material conformance test:

- a. The GCL manufacturer will replace the roll of GCL that is in non-conformance with this CQA Plan with a roll that meets the requirements of this CQA Plan.
- b. The GCL manufacturer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to the requirements of this CQA Plan. If

either of these samples fails, then the next numerical roll will be tested until a passing roll is found. If either of the two closest rolls fails, the CQA Engineer will dictate the frequency of additional testing. The CQA Engineer will document actions taken in conjunction with material control test failures.

C. GCL INSTALLATION

1. HANDLING AND PLACEMENT

The CQC Engineer will monitor and document the installation of the GCL according to this CQA Plan and the manufacturer's installation recommendations.

If the GCL has a woven geotextile side and a non-woven geotextile side, the CQC Engineer will document which geotextile side of the GCL is placed against the soil liner and which side is placed against the textured HDPE geomembrane.

2. SEAMS AND OVERLAPS

The CQC Engineer will monitor and document that the GCL is seamed or overlapped in accordance with this CQA Plan.

3. REPAIRS

The CQC Engineer will observe and document the repair of any holes or tears in the GCL, according to this CQA Plan.

4. PLACEMENT OF OVERLYING MATERIAL

The CQC Engineer will monitor and document placement of materials located on top of the GCL in accordance with this CQA Plan.

D. DEFICIENCIES

The CQC Engineer will determine the extent and nature of all defects and deficiencies and report them to Georgia Power and to the Contractor. All defects and deficiencies will be properly documented by the CQC Engineer. The CQC Engineer will observe all retests on repaired defects after the Contractor corrects the defects and deficiencies according to the CQA Plan and/or the technical specifications.

5. BOTTOM LINER GEOMEMBRANE

A. GENERAL

The CQA Engineer will certify that the bottom liner geomembrane materials and installation are in accordance with the approved permit, technical specifications, and this CQA Plan.

B. MATERIAL

1. The geomembrane will be a minimum 60 mil Textured High Density Polyethylene (HDPE) supplied and installed by firms approved by Georgia Power.
2. Seams for providing watertight joints will be extrusion or double hot wedge fusion seams.
3. The textured material will have an interface shear resistance with contiguous liner components of 23 degrees or as directed by the Design Engineer. This interface shear resistance is the minimum shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combination that provide satisfactory factors of safety may be approved by the Design Engineer. The interface shear strength will be determined by direct shear testing conducted at normal loads directed by the Design Engineer.
4. Manufacturer Quality Control (QC) will confirm that the material meets the minimum physical properties a 60-mil thick HDPE geomembrane as listed in the latest version of GRI-GM13- *Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes*.

C. GEOMEMBRANE MANUFACTURER AND INSTALLER

1. The Geomembrane Installer will submit the following information obtained from the Geomembrane Manufacturer to the CQA Engineer:
 - a. Production Certification including project references
 - b. Testing Program of Compound Ingredients
 - c. Material Certification
 - d. Test Data for Material and Resin

2. All of the above submittals will be reviewed and retained by the CQA Engineer. The Geomembrane Installer will submit the following information to the CQA Engineer 14 days prior to the installation:
 - a. Qualifications of Geomembrane Installer Superintendent and Foreman
 - b. Resumes of Geomembrane Contractor field crew
 - c. Six (6) sets of proposed geomembrane panel layout drawings

D. GEOMEMBRANE INSTALLATION

1. A pre-deployment CQA meeting will be held prior to installation of the geomembrane. The Contractor, the Geomembrane Installer, the CQA Engineer, the CQC Engineer, and representatives of Georgia Power will attend. The following issues will be discussed and agreed upon by all parties and will be included in a report in the CQA documentation.
 - a. Testing of welds.
 - b. Characteristics of “good” weld, and
 - c. Repair procedures
2. The CQC Engineer will obtain samples of the geomembrane rolls from the manufacturing plant prior to shipment to the site.
3. Random samples must be representative of the material supplied and exclude the outer wrap of geomembrane. Samples should be full roll width and at least two (2) feet long.
4. The laboratory testing of the samples selected will be coordinated by the CQC Engineer and will confirm conformance with the properties listed in the table below:

Geomembrane Conformance Testing Requirements

TEST NAME	TEST METHOD	MINIMUM TESTING FREQUENCY ⁽¹⁾
Density	ASTM D 1505 or ASTM D 792	See Note 1
Thickness	ASTM D 5994	
Tensile Strength at Yield	ASTM D 6693, Type IV	
Tensile Strength at Break		
Elongation at Yield		
Elongation at Break		
Carbon Black Content	ASTM D 1603 or ASTM D 4218	
Interface Shear Strength ⁽²⁾ (with GDM and GCL)	ASTM D5321	1 per 10 acres (min. 2 per project) per interface

Notes:

⁽¹⁾ The minimum number of rolls to be sampled for each shipment will be determined by computing the cube root of the total number of rolls delivered in the shipment, and rounding this value upward to the nearest integer, with at least one sample per each manufacturer's lot. For instance, if 40 rolls of geomembrane are delivered in a shipment, at least four rolls will be sampled. Testing will be performed at a minimum frequency of one per lot or as described above, whichever is more frequent. A lot will be as defined by ASTM D 4354.

⁽²⁾ Testing parameters for interface shear strengths are provided in Section 5.B.1

5. The CQC Engineer will review the geomembrane thickness of each roll made for the project prior to shipment. Material that does not fall within acceptable thickness criteria will be rejected.
6. The CQC Engineer will mark all areas where grinding is considered to be excessive. The location and repair method for the excessive grinding will be recorded in the daily field reports.
7. Overheating of the geomembrane during welding will be monitored by the CQC Engineer. At the discretion of the CQC Engineer, coupons will be cut from the end of the extrusion seams and the bottom side of the seam will be observed for visible warping or deformation. The location and repair method of overheated areas will be recorded in the daily field reports. The method of repair will be determined in the field by the CQC Engineer.
8. During seaming, the CQC Engineer will observe the seams for the following:
 - a. proper preparation,
 - b. grinding technique, where applicable, and
 - c. overheating

9. The CQC Engineer will observe the geomembrane during the coolest part of the day to check for slack. Any areas where excessive "trampolining" occurs will be marked by the CQC Engineer for repair by the Geomembrane Installer.
10. The CQC Engineer will mark all areas where the geomembrane indicates a protrusion from the low-permeability soil liner or GCL. The method of repair will be determined in the field by the CQC Engineer.

E. TEST SEAMS

1. The CQC Engineer will document and verify that the Geomembrane Installer performs a test seam for each welding machine in use every 4-5 hours, or at a minimum prior to start of construction work, and at midday. At least one test seam will be made for each machine in use for each seam. Should any postproduction test seam fail, the immediate prior production seam will be sampled for destructive testing in accordance with Section F below. The test seam should be approximately 5 feet long. The CQC Engineer will sample the test seam from the center 3 feet of the test sample.
 - a. The date, time, and equipment, as well as welding temperature, and seaming parameters will be recorded for each test seam.
 - b. A minimum of five (5) specimens for peel and for shear from each sample will be tested for the properties listed in the latest version of GRI-GM19, "*Standard Technical specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392. Testing will be performed in the field by the Geomembrane Installer under full-time observation by the CQC Engineer.
 - c. Untested portions of the test seam will be retained by the CQC Engineer for the project record and future testing as required.
2. All test seams must pass the field testing before production seaming is performed by the Geomembrane Installer.

F. FIELD DESTRUCTIVE TESTING

1. The Geomembrane Installer will obtain approximately 12" x 48" samples of field seams, suitable for testing, as indicated in the table below. The date, time, equipment, and seam number will be marked on each sample and recorded by the CQC Engineer.

Field Seam Testing Requirements

TEST NAME	TEST METHOD	AVERAGE TESTING FREQUENCY
Seam Peel Strength	ASTM D 6392 ⁽¹⁾	1 test per 500 feet of seam
Seam Shear Strength	ASTM D 6392 ⁽²⁾	1 test per 500 feet of seam

Notes:

⁽¹⁾ For double wedge fusion seams, both tracks will be tested in peel.

⁽²⁾ For shear tests, the sheet will yield before failure of the seams.

2. Samples retained will be tested in the field by the Geomembrane Installer. A minimum of five (5) specimens from each sample for peel and for shear will be tested for the properties listed in latest version of GRI-GM19, "*Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392.
3. The CQC Engineer or Georgia Power may require additional random samples to be taken for testing in areas that visually appear defective and not in accordance with this CQA Plan or the technical specifications.

G. NON-DESTRUCTIVE TESTING

1. The Geomembrane Installer is responsible for the completion of non-destructive testing of the entire length of all field seams, verifying that said seam is airtight. Said testing can be a vacuum test, pressure test, or approved equal and will be described by the Geomembrane Installer and verified by the CQC Engineer in advance.
2. The CQC Engineer will observe all non-destructive testing on a full-time basis.

H. DESTRUCTIVE LABORATORY TESTING

1. Destructive seam samples will be laboratory tested by the CQC Engineer. Testing frequency will be a minimum average frequency of one (1) sample per 500 linear feet of field seam.
 - a. Test samples will be at least 12 x 36 inches. A minimum of five (5) specimens will be tested for the properties listed in the latest version of GRI-GM19, "*Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392. These test samples will be taken at the same locations as the contractor's destructive testing samples.

- b. All laboratory specimens will be conditioned for a minimum of one (1) hour prior to testing at the standard atmosphere for testing geosynthetics, that is, air maintained at a relative humidity of $65 \pm 5\%$ and a temperature of $21 \pm 2^{\circ}\text{C}$ ($70 \pm 3.5^{\circ}\text{F}$).
 - c. Peel tests will be performed on both sides of a double-wedge fusion seam.
- 2. The load and elongation at failure will be measured for each specimen. The CQC Engineer will describe the type of failure for each specimen and record the presence of any disbonding, delamination, foreign material in the bond area, etc.
 - 3. The average values of each set of five specimens for peel and for shear must meet this CQA Plan, and four of the five specimen tests must meet this CQA Plan for the seam to be considered a passing seam. If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80 percent of the values required for the seam for the sample to pass. A maximum of one non-film tear bond failure out of five tests is acceptable provided the destructive sample meets strength requirements discussed above. If unresolved discrepancies exist between the CQC Engineer and Contractor's test results, the archived sample may be tested by the CQC Engineer. Samples that do not pass the shear and peel tests will be resampled from locations at least 10 feet on each side of the original location. These two re-test samples must pass both shear and peel testing. If these two samples do not pass, then additional samples will continue to be obtained until the questionable seam area is defined.
 - 4. Seams represented by a failing destructive field or laboratory test sample will be cut out and replaced or covered with a cap strip and the seam bounded by supplemental passing field and laboratory destructive test samples at both ends.
 - 5. The CQC Engineer will verify and document that the strength and other properties of the 60-mil thick HDPE geomembrane seams meet or exceed the requirements set forth in the latest version of GRI-GM19, *"Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane"*.

I. LEAK LOCATION SURVEY (IF APPLICABLE)

- 1. If performed, Leak Location Survey(s) on the landfill bottom geomembrane liner will be observed and documented by the CQC Engineer. The work will be performed according to this CQA Plan.
- 2. The CQC Engineer will verify that the Leak Location Contractor has the following qualifications for conducting the Leak Location Survey:

- a. Completion of the Liner Integrity Survey/Assessment (LISA) training course conducted by TRI Environmental of Austin, Texas (or equivalent).
 - b. The leak location surveys must be supervised by a professional or technician with a minimum of three (3) years and 5,000,000 square feet of geomembrane installation and CQA experience.
 - c. The leak location supervisor must be on site full-time during the performance of the Leak Location Survey.
3. Leak Location Survey(s) will meet the requirements of:
 - a. ASTM D6747 – Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes; and
 - b. ASTM D7007 – Standard Practices for Locating Leaks in Geomembranes Covered with Water or Earth Materials.

The selected method will have the goal of identifying minimum 1-inch dimension penetrations in the geomembrane, unless otherwise specified in this CQA Plan.
4. The CQC Engineer will confirm and document that the Leak Location Survey is conducted after the protective cover materials are installed over the geomembrane liner to detect holes resulting from construction damage during placement of the protective cover layer.
5. The CQC Engineer will document the Leak Location Contractor's site inspection prior to commencing the survey to confirm all site preparations are completed and the site conditions are appropriate for conducting the Leak Location Survey. Any issues or concerns with the site conditions will be reported to the Contractor, the Geosynthetics Installers, Georgia Power, and documented by the CQC Engineer.
6. Leak Location Contractor will mark the locations of all identified or indicated leaks with flags, spray paint, or written coordinates. All liner repairs will be completed, observed and documented by the CQC Engineer.
7. The CQC Engineer will include the Leak Location Contractor's report in the project Construction Certification Report.

6. LEACHATE COLLECTION GEOCOMPOSITE DRAINAGE MEDIA (GDM)

A. GENERAL

The CQA Engineer will certify that the leachate collection geocomposite drainage media (GDM) materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. GDM MANUFACTURER AND INSTALLER

1. The CQA Engineer will review and verify the following submittals from the GDM manufacturer:
 - A. Production Certification,
 - B. Material Certification, and
 - C. Test Data for Material.
2. The CQA Engineer will review and verify the following information prior to installation:
 - A. Qualifications of installer superintendent, foreman, and field crew.
 - B. Six sets of field installation drawings.

C. CONFORMANCE TESTING

CQA Conformance Testing will be performed by the CQC Engineer according to the following table:

GDM Conformance Testing Requirements

TEST NAME	TEST METHOD	MINIMUM TESTING FREQUENCY ⁽¹⁾
Transmissivity ⁽²⁾	ASTM D 4716 - Modified (100-hour transmissivity of geocomposites)	1 test per 10 acres (minimum 2 per project)
Adhesion	ASTM D 7005	1 test per 200,000 s.f.
Resin Density	ASTM D1505	1 test per 200,000 s.f.
Interface Shear Strength ⁽³⁾ (with protective layer)	ASTM D5321	1 test per 10 acres (min. 2 per project)

Notes:

⁽¹⁾ Testing will be performed at a frequency of one per lot or at listed frequency, whichever is more frequent. A lot is defined by ASTM D 4354.

⁽²⁾ Transmissivity testing will be performed as described below:

For Cell 2, conduct CQA testing for transmissivity at the confining pressure of 11,000 PSF at a hydraulic gradient equal to 0.01. The boundary conditions are "Granular Drainage Layer" gravel on top and the specified geomembrane on the bottom of the GDM. The minimum required transmissivity tested under these conditions will be 1.1×10^{-3} m²/sec (testing between two steel plates are not acceptable).

For Cell 3, conduct CQA testing for transmissivity at the confining pressure of 8,200 PSF at a hydraulic gradient equal to 0.02. The boundary conditions are the specified protective sand layer/primary filter on top and the specified geomembrane on the bottom of the GDM. The minimum required transmissivity tested under these conditions will be 1.4×10^{-3} m²/sec (testing between two steel plates are not acceptable).

⁽³⁾ The GDM will have an interface shear resistance with contiguous liner components of 23 degrees or as directed by the Design Engineer. This interface shear is the minimum shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer. The interface shear strength will be determined by direct shear testing conducted at normal loads directed by the Design Engineer.

Conformance testing for the individual components of the GDM (geotextile and the geonet) will be in accordance with this CQA Plan and the technical specifications.

D. INSTALLATION

1. The CQC Engineer will verify that the installation of the GDM proceeds after he has provided certification of the geomembrane or a section thereof.
2. The CQC Engineer will monitor the installation of the GDM to verify there is no damage to the geomembrane liner. Should the geomembrane liner be damaged the CQC Engineer will inform the Contractor and document the repairs done.

3. The CQC Engineer will verify that adjacent rolls of GDM overlap a distance of at least three (3) inches and are secured using polyethylene ties every ten (10) feet for adjacent rolls and five (5) feet at end seams.
4. The CQC Engineer will verify that the overlaying GDM geotextile, where applicable, extends at least six (6) inches past the geonet joint and is permanently bonded by heat bonding or sewing.
5. The CQC Engineer will verify that any GDM that is torn, crushed, or punctured is repaired or replaced by the Contractor according to this CQA Plan.
6. The CQC Engineer will be present during all installation operations and will verify that all work is in accordance with the CQA Plan and technical specifications.
7. At the conclusion of this activity, the CQC Engineer will provide a written certification that the work has been installed according to plans and technical specifications.

7. PROTECTIVE SAND LAYER/PRIMARY FILTER AND GRANULAR DRAINAGE LAYER

A. GENERAL

The CQA Engineer will certify the protective sand layer/primary filter and granular drainage layer materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. MATERIALS

1. The protective sand layer/primary filter layer will be a loose granular material resulting from the disintegration of rocks, will be capable of 100% passing through a $\frac{3}{8}$ -inch screen and will generally conform to the gradation of a Georgia DOT 10 NS or 10 SM sand. The protective sand layer material will contain no aggregate rocks, debris, plant material, material with sharp edges, lignite, coal, ash, or carbonaceous material. By-products of industrial processes, with the exception of quarry grinding operations, will not be accepted. This material will be utilized in Cell 3 for the full 24-inch thick protective sand layer/primary filter layer except where stone is specified in the plans, and in the 12-inch thick protective sand layer/primary filter layer in Cell 2.
2. The protective sand layer/primary filter layer will consist of a material with a permeability equal to or greater than 1×10^{-2} cm/sec.
3. Material for the granular drainage layer (lower 12 inches in Cell 2) will meet the gradation requirements of a Georgia DOT No. 8 Stone and will have a permeability of no less than 3.25 cm/sec. The granular drainage layer material will contain no debris, plant material, material with sharp edges, lignite, coal, ash, or carbonaceous material. By-products of industrial processes, with the exception of quarry grinding operations, will not be accepted.
4. The slope GDM will be covered with 12 inches of protective sand layer/primary filter under 12 inches of NSA R-2 stone.
5. Construction Quality Assurance Testing will meet the minimum requirements for the protective sand layer/primary filter and granular drainage layers as follows:

Test	Minimum Frequency
Grain Size to No. 200 Sieve (ASTM D 422)	1 per material per acre
Permeability* (ASTM D 2434)	1 per material per 5,000 cy

Test	Minimum Frequency
Carbonate Content (ASTM D3042)	1 per material per 10,000 cy

*does not include NSA R-2 material

C. STOCKPILING AND MATERIAL APPROVAL

1. All material to be used as protective sand layer/primary filter layer and granular drainage layer will be approved in advance by the CQC Engineer. The CQC Engineer must verify that the sand and the stone meet all the material requirements.
2. Verification can be accomplished during excavation and stockpiling or prior to use at existing stockpiles.
3. The CQC Engineer will prepare reports of all testing, analysis, and verification.

D. CONSTRUCTION

The CQA Engineer will verify the following information:

1. Approved material was used to construct the protective filter sand and granular drainage layers.
2. The underlying geosynthetics were not damaged during placement of the protective filter sand and granular drainage layers.
3. The granular material was placed from the toe of the slope up.
4. The protective sand layer/primary filter and granular drainage layer was constructed in accordance with the approved permit drawings, technical specifications, and this CQA Plan.
5. The required protective filter sand and granular drainage thicknesses were achieved.

8. LEACHATE COLLECTION SYSTEM TRENCHES

A. GENERAL

The CQC Engineer will certify the leachate collection system trench materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. MATERIALS

The CQC Engineer will verify that the leachate collection system trench materials delivered to the site are as follows:

1. Leachate collection piping in accordance with the leachate piping technical specifications and this CQA Plan.
2. Gravel for leachate pipe encasement and for the leachate sump will be in accordance with the gravel technical specifications and this CQA Plan.
3. Cushion Geotextile will be a non-woven geotextile of polypropylene fibers or polyester yarns suitable for separation and cushioning. The cushion geotextile will be in accordance with the cushion technical specifications and this CQA Plan.

The CQC Engineer will verify that all materials provided are those specified or are equal and are in accordance with the approved permit drawings, technical specifications, and this CQA Plan.

C. INSTALLATION

1. The CQC Engineer will verify and document that the installation of the leachate collection system proceeds after he/she has received/reviewed all of the destructive test results of the geomembrane liner and has reviewed and approved the geomembrane liner as-built survey.
2. The CQC Engineer will verify there is no damage to the underlying geosynthetic materials during the installation of the leachate collection system. If the CQC Engineer notices damage of the underlying geosynthetics, the CQC Engineer will inform the Contractor and will verify that the Contractor makes the required repairs.
3. The CQC Engineer will be present during all phases of the leachate collection system construction and will verify that all work is in accordance with the approved permit drawings, technical specifications and this CQA Plan.

D. QUALITY ASSURANCE

The CQC Engineer will document and verify that the following submittals are provided and that the materials meet and are installed in accordance with the technical specifications and this CQA Plan.

1. HIGH DENSITY POLYETHYLENE PIPE

- a. Submittals required for pipe:
 - i. Compliance with applicable ASTM standard
 - ii. Unit weight
 - iii. Diameter and SDR
 - iv. Physical dimensions
 - v. Method of jointing with instructions
 - vi. Nominal pipe joint lengths
 - vii. Recommended bedding and installation details
 - viii. Instructions and tables or information on strength of each pipe type versus bury
 - ix. Conditions of depth and traffic loadings
 - x. Certification by manufacturer that material properties meet the values listed in the material properties sheet.
 - xi. Perforation diameter and spacing
- b. The CQC Engineer will document and verify that the manufacturer certifies that the pipe supplied is represented by the quality assurance data.
- c. The CQC Engineer will inform the Contractor when the pipe does not meet appropriate ASTM Standards.
- d. The CQC Engineer will provide results of any samples taken for testing.
- e. The CQC Engineer will witness and verify that jointing and installation are in accordance with manufacturer's recommendations and this CQA Plan.
- f. The CQC Engineer will verify that leachate conduits external to the collection system are tested and demonstrated to be leak-proof.

2. PIPE ENCASUREMENT GRAVEL

- a. The CQA Engineer will review the Contractor's submittals on gravel for conformity to technical specifications including quarry's certification of gradation.
- b. Construction Quality Control Testing will meet the minimum requirements for the encasement gravel as follows:

Test	Minimum Frequency
Grain Size (ASTM D 422)	2 per project per material
Carbonate Content (ASTM D3042)	1 per material per 10,000 cy

- c. The CQC Engineer will inform the Contractor when the gravel does not meet the requirements of this CQA Plan or the technical specifications.
- d. The CQC Engineer will provide results of any samples taken for testing.
- e. The CQC Engineer will verify that the gravel encasement is in accordance with the technical specifications and this CQA Plan.

3. CUSHION GEOTEXTILE

- a. The CQC Engineer will review the Contractor's submittals on geotextile for conformity to technical specifications.
- b. The CQC Engineer will inform the Contractor when the geotextile does not meet technical specifications.
- c. The CQC Engineer will verify that the geotextile is in accordance with the technical specifications and this CQA Plan.
- d. The CQC Engineer will provide results of any samples taken for testing.

9. TESTING OF PIPING SYSTEMS

A. GENERAL

1. The CQC Engineer will observe and document leak testing of leachate manholes, force mains, and non-perforated gravity piping.
2. If the specified rate of leakage is exceeded during the test, the CQC Engineer will document that the Contractor located the points of excessive leakage, instituted appropriate measure of correction, and observed all re-tests, until test requirements are met.
3. The CQC Engineer will observe and confirm that:
 - a. Hydrostatic testing is performed on force mains and pressure leachate piping.
 - b. Exfiltration testing is performed on manholes and gravity leachate piping.

B. EXFILTRATION TESTING

1. The CQC Engineer will verify and document that the exfiltration tests on all manholes and gravity leachate piping are conducted according to the following procedures:
 - a. Plug each end of section or all openings to manhole to be tested with watertight bulkheads.
 - b. Insert in each bulkhead at the top of the pipeline a two (2") inch diameter pipe with 90° elbow that will extend four (4') feet vertically above the top of the pipeline or above the groundwater line, whichever is higher. Manhole will be tested at full depth with the water level at the cover ring.
 - c. The elevations of the top of the two (2") inch diameter pipe at each bulkhead will be the same.
 - d. Fill the pipeline with clear water until the water level is at the top of the two (2") inch diameter pipe at the upper end of section or at the manhole ring.
 - e. Maintain the water level by adding accurately measured amounts of water for a period of thirty minutes, not allowing the lower pipe to overflow.
 - f. The maximum length of a section of pipeline to be tested by means of an exfiltration test at one time will be limited to 1,000 linear feet.

- g. The maximum permissible leakage determined by exfiltration will be the rate of 25 gallons per in. inside diameter of pipe per mile of pipe per 24 hours, inclusive of all appurtenances within the section such as manholes, valves, etc. The length of pipe used in the computation will be the horizontal distance between manhole centerlines of the section being tested. The maximum permissible leakage rate for manholes tested alone will be 0.01 gallons per vertical foot per day.
- h. Once exfiltration is found to be within allowable limits, remove all bulkheads.

C. HYDROSTATIC TESTING

- 1. The CQC Engineer will observe and document all hydrostatic tests for the following piping systems:
 - a. All pressure leachate piping and force mains.
 - b. Do not test piping systems with water where water testing will be harmful to the system operation, such as for air and gas piping systems.
 - a. All piping that will be considered inaccessible or impossible to repair after the completion of the work will be hydrostatically tested while still accessible.
 - i. Examples of such piping are those near or under basins, paved roads, concrete structures, and concrete foundation.
 - c. The CQC Engineer will document that all piping have reaction blocking (thrust blocks) in place before testing.
- 2. The CQC Engineer will verify and document that the hydrostatic tests are conducted according to the following procedures:
 - a. Each section of pressure pipe or force main will be filled slowly with water and the specified test pressure, measured at the point of the lowest elevation, will be applied to the pipe in a satisfactory manner. The Contractor will furnish all test water and test equipment.
 - b. Before applying the specified test pressure, all air will be expelled from the pipe. To accomplish this, taps will be made, if necessary, at points of highest elevation, and afterward tightly plugged.
 - c. The test pressure will be maintained for a sufficient length of time prior to the test to allow for thorough examination of joints and elimination of leakage where necessary. The pipeline will be made watertight under the test pressure.

- d. The Contractor and the CQC Engineer will inspect all exposed pipes, fittings, valves, hydrants, and joints during the test. Any cracked or defective pipes, fittings, valves, or hydrants discovered in consequence of this pressure test will be removed and replaced with sound material and the test will be repeated to the satisfaction of the CQC Engineer.
- e. Hydrostatic test pressures will be as follows:

System	Pressure Test Rating (psi)
Miscellaneous Pressure Pipe	100
Pressure Leachate Piping (force main)	100
Secondary Containment Piping	Max. Pressure Plus 10 psi

- a. The test section will be pressurized to the required test pressure.
- b. The test will be conducted for a minimum of one (1) hour.
- c. The test section will not be accepted if it has any observed leakage or the test pressure drops more than one (1) psi during the leakage test.

10. FINAL COVER SYSTEM LOW-PERMEABILITY SOIL LAYER (INFILTRATION LAYER)

A. GENERAL

The CQA Engineer will confirm and certify that the material used to construct the final cover low-permeability soil layer is in accordance with the approved closure plan, technical specifications, and this CQA Plan.

B. MINIMUM REQUIREMENTS

The low-permeability soil layer material will consist of cohesive soils capable of being placed and compacted to meet the permeability criterion of $k \leq 1 \times 10^{-5}$ cm/sec.

C. PRE-CONSTRUCTION MATERIAL EVALUATION

1. All material to be used to construct the final cover low-permeability soil layer will be sampled and tested by the CQC Engineer in advance of being placed. Such testing can be performed during excavation of the borrow area or from existing stockpiles.
2. The procedure for pre-construction testing of material to be used for low-permeability soil layer on the final cover system is outlined below:
 - a. The CQC Engineer will visually examine each load of soil either at the borrow source or the stockpile area. Soil that does not meet the requirements in the CQA Plan or the technical specification for low-permeability soil layer material will be rejected or routed to separate stockpiles.
 - b. The following tests will be performed at the frequencies listed in the CCR Landfill Final Cover Soil Layer Construction Quality Assurance Testing Requirements Table on Page 35 of this plan, prior to placement of any low-permeability soil layer material:
 - i. Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D2216.
 - ii. Method for Particle - Size Analysis of Soils, ASTM D422 (Mechanical Sieve Method Only).
 - iii. Test Method for Liquid Limit, and Plasticity Index of Soils, ASTM D4318,
 - iv. Moisture-Density Curve (ASTM D698), and
 - v. One (1) sample for every 10,000 cubic yards of material stockpiled will be selected for remolded permeability testing (ASTM D5084 -

Measurement of Permeability of Saturated Porous Materials using a Flexible Wall Permeameter).

3. Reports for low-permeability soil layer will be prepared by the CQC Engineer and will include:
 - a. Summary of laboratory test data, and
 - b. A summary of construction, sampling and testing method, and recommendations for placement of the final cover low-permeability soil layer.

D. TEST PAD FOR LOW-PERMEABILITY SOIL LAYER

1. The CQC Engineer will document the construction of a test pad prior to or coinciding with, the beginning of construction of the final cover low-permeability soil layer component.
2. The CQC Engineer will sample and test soil samples obtained from the constructed test pad to confirm that the material used, and the Contractors' placement and compaction methods used can consistently produce a final cover low-permeability soil layer that meets the requirements of the CQA Plan and the technical specifications.
3. The CQC Engineer will confirm that the Contractor uses the same placement and compaction methods, equipment, and material to construct the remaining final cover low-permeability soil layer.

E. CONSTRUCTION

1. Only soil from a source previously sampled, tested and confirmed to meet the requirements of this CQA Plan and the technical specifications will be used in construction of the low-permeability soil layer. The CQC Engineer will notify the Contractor when material does not meet the requirements of the technical specification and will document that this material will not be used for final cover low-permeability soil layer construction.
2. The CQC Engineer will complete all required field density and moisture content tests before the overlying lift of final cover low-permeability soil is placed.
3. The CQC Engineer will observe and document that the Contractor completes all prior lift surface preparation (e.g., wetting, drying, scarification, etc.) before placement of subsequent lifts.

4. The CQC Engineer will observe and document that loose lift thicknesses do not exceed 10" (unless otherwise required in the technical specifications) for a final 6" compacted lift thickness.
5. The CQC Engineer will check each lift visually for rocks, debris, plant materials, and other foreign material, as well as particle sizes or clods that exceed the requirements set forth in this CQA Plan. The CQC Engineer will inform the Contractor if such materials are found and will document their removal.
6. The CQC Engineer will observe and document that the exposed surface of the final cover low-permeability soil layer is rolled with a smooth drum roller or equivalent at the end of each work day or when required to protect the compacted soil from adverse weather conditions.
7. The CQC Engineer will observe and document that the exposed surface of the final cover low-permeability soil layer is reasonably free of rock, rock fragments, or loose materials. The CQC Engineer will observe and document that rock or other materials protruding more than ¼-inch and other loose materials are removed, all cracks or voids filled, and the surface made uniform.
8. As-built certification surveys will be performed on the low-permeability soil layer prior to installing the overlying geosynthetics materials. Due to settlement and consolidation of underlying CCR, which may occur during final cover system construction, the as-built certification points may not accurately provide actual thickness of the low-permeability soil layer. In such cases, the CQC Engineer will perform hand augers to confirm that the required thickness of the low-permeability soil layer has been achieved. Results of the thickness confirmation borings will be documented by the CQC Engineer in the CQA Construction Certification Report. All holes will be patched with sodium bentonite pellets, mixed with low-permeability soils in the holes, hydrated and compacted.
9. The CQC Engineer will observe and document that the surface on which the geosynthetics is to be placed is maintained in a firm, clean, dry, and smooth condition before and during the geosynthetics installation. Additionally, the CQC Engineer will inform the Contractor when desiccation cracking is excessive and will document that all desiccation cracks are repaired.
10. The CQC Engineer will inspect the final cover low-permeability soil layer and certify that it is constructed in accordance with the approved permit, the technical specifications and this CQA Plan.

F. SAMPLING AND TESTING

1. Construction Quality Control sampling and testing will meet the minimum requirements indicated in the Table below.
2. The CQC Engineer or his /her representative will randomly determine the location of each test. All holes will be filled with a mixture of low-permeability soil and sodium bentonite pellets hydrated and compacted in the holes.

CCR Landfill Final Cover Soil Layer Construction Quality Assurance Testing Requirements			
Item	Testing	Frequency	Minimum Criteria
Soil Layer Borrow Source	Grain Size (sieves only) (ASTM D422)	1,000 yd ³	<2" (99.8% of all tests) and <1/4" (top 6", 99% of all tests) $k \leq 1.0 \times 10^{-5}$ cm/sec
	Moisture Content (ASTM D2216)	2,000 yd ³	
	Atterberg Limits (ASTM D4318)	5,000 yd ³	
	Moisture-Density Curve (ASTM D698)	5,000 yd ³ and all changes in material	
	Permeability (remold) (ASTM D5084)	10,000 yd ³	
Soil Layer During Construction	Density/Moisture-Nuclear, Drive-Cylinders, or Sand Cone (ASTM D6938, D2937 or D1556)	1 test/10,000 sf/lift	≥95% Standard Proctor
Laboratory Testing on Undisturbed Samples of the Constructed Soil Layer	Undisturbed Permeability (ASTM D5084)	1 test/40,000 sf/lift	$k \leq 1.0 \times 10^{-5}$ cm/sec
	Dry Density (ASTM D6938)		
	Moisture Content (ASTM D2216)		
	Atterberg Limits (ASTM D4318)		

3. The CQC Engineer will follow this procedure in the event of a density or permeability test failure. If the density does not meet minimum requirements of the CQA Plan, recompaction of the failed area (minimum 100 feet x 100 feet) will be performed and

retested until the area meets or exceeds requirements outlined in the CQA Plan. If a permeability sample fails to meet the minimum permeability requirements outlined in the CQA Plan, the area of failing permeability (minimum 40,000 sf) will be reconstructed. Optionally, at least four (4) replicate samples will be obtained in the immediate vicinity of the failed test. Should the replicate samples confirm the failure of the low-permeability soil layer to meet the requirements set forth in this CQA Plan, the area of failure will be localized according to the results of the replicate samples and reconstructed in accordance with the CQA Plan. All areas of reconstruction will be retested as outlined in the CQA Plan.

11. FINAL COVER SYSTEM GEOMEMBRANE

A. GENERAL

The CQC Engineer will certify the final cover system geomembrane materials and installation are in accordance with the approved permit, technical specifications, and this CQA Plan.

B. MATERIAL

1. The final cover system geomembrane will be a minimum 40-mil Textured Linear Low-Density Polyethylene (LLDPE) supplied and installed by firms approved by Georgia Power.
2. Seams for providing watertight joints will be extrusion or double hot wedge fusion seams.
3. The textured material will have an interface shear resistance (friction angle plus cohesion) with contiguous final cover system components of 24.8 degrees or as directed by the Design Engineer. This interface shear is the minimum shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer. The interface shear strength will be determined by direct shear testing conducted at loads directed by the Design Engineer.
4. Manufacturer Quality Control will confirm that the material meets the minimum physical properties of a 40-mil thick textured LLDPE geomembrane as listed in the latest version of GRI-GM17, *"Test methods, test properties and testing frequency for Linear Low-Density Polyethylene (LLDPE) smooth and textured geomembrane"*.

C. GEOMEMBRANE MANUFACTURER AND INSTALLER

1. The Geomembrane Installer will submit the following documents as obtained from the Geomembrane Manufacturer to the CQA Engineer:
 - a. Production Certification, including project references,
 - b. Testing Program of Compound Ingredients,
 - c. Material Certification, and
 - d. Test Data for Material and Resin

All of the above submittals will be reviewed and retained by the CQA Engineer.

2. The Geomembrane Installer will submit the following documents to the CQA Engineer 14 days prior to installation:
 - a. Qualifications of Geomembrane Installer Superintendent and Foreman,
 - b. Resumes of Geomembrane Contractor field crew, and
 - c. Six (6) sets of proposed geomembrane panel layout drawings.

D. GEOMEMBRANE INSTALLATION

1. A pre-deployment CQA meeting will be held prior to installation. The Contractor, the Geomembrane Installer, the CQA Engineer, the CQC Engineer, and a representative of Georgia Power will be in attendance. The following issues will be discussed and agreed upon by all parties and will be included in a report in the CQA documentation.
 - a. Testing of welds
 - b. Characteristics of a "good" weld, and
 - c. Repair procedures
2. The CQC Engineer will obtain samples of the geomembrane rolls from the manufacturing plant prior to shipment to the site.
3. Random samples must be representative of the material supplied and exclude the outer wrap of geomembrane. Samples should be full roll width and at least two (2) feet long.
4. The laboratory testing of the samples selected will be coordinated by the CQC Engineer and will confirm conformance with the properties listed in the table below:

Geomembrane Conformance Testing Requirements

TEST NAME	TEST METHOD	MINIMUM TESTING FREQUENCY ⁽¹⁾
Density	ASTM D 1505 or ASTM D 792	See Note 1
Thickness	ASTM D 5994	
Tensile Strength at Yield	ASTM D 6693, Type IV	
Tensile Strength at Break		
Elongation at Yield		
Elongation at Break		
Carbon Black Content	ASTM D 1603 or ASTM D	

TEST NAME	TEST METHOD	MINIMUM TESTING FREQUENCY ⁽¹⁾
	4218	
Interface Shear Strength ⁽²⁾ (with geocomposite and low permeability soil layer)	ASTM D5321	1 per 10 acres (minimum 2 per project) per interface

Notes:

⁽¹⁾ The minimum number of rolls to be sampled for each shipment will be determined by computing the cube root of the total number of rolls delivered in the shipment and rounding this value upward to the nearest integer, with at least one sample per each manufacturer's lot. For instance, if 40 rolls of geomembrane are delivered in a shipment, at least four rolls will be sampled. Testing will be performed at a minimum frequency of one per lot or as described above, whichever is more frequent. A lot will be as defined by ASTM D 4354.

⁽²⁾ Testing parameters for interface shear strengths are provided in Section 11. B.3.

5. The CQC Engineer will review the geomembrane thickness of each roll made for the project prior to shipment. Material that does not fall within acceptable thickness criteria will be rejected.
6. The CQC Engineer will mark all areas where grinding is considered to be excessive. The location and repair method for the excessive grinding will be recorded in the daily field reports.
7. Overheating of the geomembrane during welding will be monitored by the CQC Engineer. At the discretion of the CQC Engineer, coupons will be cut from the end of the extrusion seams and the bottom side of the seam will be observed for visible warping or deformation. The location and repair method of overheated areas will be recorded in the daily field reports. The method of repair will be determined in the field by the CQC Engineer.
8. During seaming, the CQC Engineer will observe the seams for the following:
 - a. proper preparation,
 - b. grinding technique, where applicable, and
 - c. overheating.
9. The CQC Engineer will observe the geomembrane during the coolest part of the day to check for slack. Any areas where excessive "trampolining" occurs will be marked by the CQC Engineer for repair by the Geomembrane Installer.

10. The CQC Engineer will mark all areas where the geomembrane indicates a protrusion from the final cover low-permeability soil layer. The method of repair will be determined in the field by the CQC Engineer.

E. TEST SEAMS

1. The CQC Engineer will document and verify that the Geomembrane Installer performs a test seam for each welding machine in use every 4-5 hours, or at a minimum prior to start of construction work, and at midday. At least one test seam will be made for each machine in use for each seam. Should any post-production test seam fail, the immediate prior production seam will be sampled for destructive testing in accordance with Section F below. The test seam should be approximately 5 feet long. The CQC Engineer will sample the test seam from the center 3 feet of the test sample.
 - a. The date, time, and equipment, as well as welding temperature and seaming parameters, will be recorded for each test seam.
 - b. A minimum of five (5) specimens for peel and for shear from each sample will be tested for the properties listed in the latest version of GRI-GM19, "*Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392. Testing will be performed in the field by the Geomembrane Installer under full-time observation by the CQC Engineer.
 - c. Untested portions of the test seam will be retained by the CQC Engineer for the project record and future testing as required.
2. All test seams must pass field-testing before production seaming is performed by the Geomembrane Installer.

F. FIELD DESTRUCTIVE TESTING

1. The Geomembrane Installer will obtain approximately 12" x 48" samples of field seams, suitable for testing, as indicated in the table below. The date, time, equipment, and seam number will be marked on each sample and recorded by the CQC Engineer.

Field Seam Testing Requirements

TEST NAME	TEST METHOD	AVERAGE TESTING FREQUENCY
Seam Peel Strength	ASTM D 6392 ⁽¹⁾	1 test per 500 feet of seam
Seam Shear Strength	ASTM D 6392 ⁽²⁾	1 test per 500 feet of seam

Notes:

- (1) For double wedge fusion seams, both tracks will be tested in peel.
(2) For shear tests, the sheet will yield before failure of the seams.

2. Samples retained will be tested in the field by the geomembrane installer. A minimum of five (5) specimens from each sample for peel and for shear will be tested for the properties listed in the latest version of GRI-GM19, *"Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane"* in accordance with test method ASTM D6392.
3. The CQC Engineer or Georgia Power may require additional random samples to be taken for testing in areas that visually appear defective and not in accordance with this CQA Plan.

G. NON-DESTRUCTIVE TESTING

1. The Geomembrane Installer is responsible for the completion of non-destructive testing of the entire length of all field seams, verifying that said seam is airtight. Said testing can be a vacuum test, pressure test, or approved equal and will be described by the Geomembrane Installer and verified by the CQC Engineer in advance.
2. The CQC Engineer will observe all non-destructive testing on a full-time basis.

H. DESTRUCTIVE LABORATORY TESTING

1. Destructive seam samples will be laboratory tested by the CQC Engineer. Testing frequency will be a minimum average frequency of one (1) sample per 500 linear feet of field seam.
 - a. Test samples will be at least 12 inches x 36 inches. A minimum of five (5) specimens will be tested for the properties listed in the latest version of GRI-GM19, *"Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane"* in accordance with test method ASTM D6392. These test samples will be taken at the same locations as the contractor's destructive testing samples.

- b. All laboratory specimens of geomembrane will be conditioned for a minimum of one (1) hour prior to testing at the standard atmosphere, that is, air maintained at a relative humidity of $65 \pm 5\%$ and a temperature of $21^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($70^{\circ}\text{C} \pm 3.5^{\circ}\text{F}$).
 - c. Peel tests will be performed on both sides of a double-wedge fusion seam.
- 2. The load and elongation at failure will be measured for each specimen. The CQC Engineer will describe the type of failure for each specimen and record the presence of any disbonding, delamination, foreign material in the bond area, etc.
 - 3. The average values of each set of five (5) specimens for peel and for shear must meet the requirements in this CQA Plan, and four of the five specimen tests must meet the requirements in this CQA Plan for the seam to be considered a passing seam. If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80 percent of the values required for the seam for the sample to pass. A maximum of one non-film tear bond failure out of five tests is acceptable provided the destructive sample meets strength requirements discussed above. If unresolved discrepancies exist between the CQC Engineer and Contractor's test results, the archived sample may be tested by the CQC Engineer. Samples that do not pass the shear and peel tests will be resampled from locations at least 10 feet on each side of the original location. These two re-test samples must pass both shear and peel testing. If these two samples do not pass, then additional samples will continue to be obtained until the questionable seam area is defined.
 - 4. Seams represented by a failing destructive field or laboratory test sample will be cut out and replaced or covered with a geomembrane strip and the seam bounded by supplemental passing field and laboratory destructive test samples at both ends.
 - 5. The CQC Engineer will verify and document that the strength and other properties of the textured 40-mil thick LLDPE geomembrane seams meet or exceed the requirements set forth in the latest version of GRI-GM19, "*Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*".

12. FINAL COVER SYSTEM GEOCOMPOSITE DRAINAGE MEDIA (GDM)

A. GENERAL

The CQC Engineer will certify the final cover system geocomposite drainage media (GDM) materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. GDM MANUFACTURER AND INSTALLER

1. The CQA Engineer will review and verify the following submittals from the GDM Manufacturer:
 - a. Production Certification,
 - b. Material Certification, and
 - c. Test Data for Material.
2. The CQA Engineer will review and verify the following documents prior to installation:
 - a. Qualifications of the GDM installer superintendent, foreman, and field crew, and
 - b. Six (6) sets of field installation drawings.

C. CONFORMANCE TESTING

Conformance Testing will be performed by the CQC Engineer according to the following table:

GDM Conformance Testing Requirements

TEST NAME	TEST METHOD	MINIMUM TESTING FREQUENCY ⁽¹⁾
Transmissivity ⁽²⁾	ASTM D4716 - Modified (100-hour transmissivity of geocomposites)	1 test per 10 acres
Adhesion	ASTM D7005	1 test per 200,000 s.f.
Resin Density	ASTM D1505	1 test per 200,000 s.f.
Interface Shear Strength ⁽³⁾ (with protective layer)	ASTM D5321	1 test per 10 acres (minimum 2 per project)

Notes:

- ⁽¹⁾ Testing will be performed at a frequency of one per lot or at the listed frequency, whichever is more frequent. A lot is defined by ASTM D 4354.
- ⁽²⁾ Transmissivity testing will be performed as described below:
Conduct CQA testing for transmissivity at the confining pressure of 250 PSF at a hydraulic gradient equal to 0.33. The boundary conditions are "Protective Cover" soils on top and the specified geomembrane on the bottom of the GDM. The minimum required transmissivity tested under these conditions will be 5×10^{-4} m²/sec (testing between two steel plates are not acceptable).
- ⁽³⁾ The GDM will have an interface shear resistance (friction angle plus cohesion) with contiguous final cover system components of 24.8 deg. (per ASTM D5321). This is the minimum shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer. The interface shear strength will be determined by direct shear testing conducted at the confining pressure of 250 psf or as directed by the Design Engineer.

Conformance testing for the individual components of the GDM (geotextile and the geonet) will be in accordance with this CQA Plan.

D. INSTALLATION

1. The CQC Engineer will verify that the installation of the GDM proceeds after he has provided certification of the geomembrane or a section thereof.
2. The CQC Engineer will monitor the installation of the GDM to verify there is no damage to the final cover system geomembrane. Should the final cover system geomembrane be damaged, the CQC Engineer will inform the Contractor and document the repairs done.
3. The CQC Engineer will verify that adjacent rolls of GDM:
 - a. Overlap a distance of at least three (3) inches; and
 - b. Are secured using polyethylene ties as follows:
 - i. every ten (10) feet for adjacent rolls, and
 - ii. every five (5) feet at end seams.
4. The CQC Engineer will verify that the overlaying geotextile, where applicable, extends at least six (6) inches past the geonet joint and is permanently bonded by heat bonding or sewing.
5. The CQC Engineer will verify that any GDM that is torn, crushed, or punctured is repaired or replaced by the GDM Installer according to this CQA Plan.
6. The CQC Engineer will be present during all placement operations and will verify that all work is in accordance with this CQA Plan.
7. At the conclusion of this activity, the CQC Engineer will provide a written certification that the work has been installed according to this CQA Plan.

13. FINAL COVER SYSTEM PROTECTIVE SOIL COVER

A. GENERAL

The CQA Engineer will verify that the final cover system protective soil cover material and installation is placed in accordance with the approved plans, technical specifications, and this CQA Plan.

B. MATERIAL

1. Soil that meets all of the following requirements will be classified as select soil fill for use in the construction of the final cover protective soil cover for the final cover system.
 - a. Soil will be classified according to the Unified Soil Classification System (USCS) as ML, MH, CH, CL or SC. (ASTM D2487). Liquid limit, plasticity index (PI), and percent passing the No. 200 sieve will be considered for proper classification.
 - b. Select soil fill materials will be reasonably free of ferrous, and/or calcareous concretions and nodules, refuse roots, or other deleterious substances.
 - c. The soil cover will be uniform, smooth, and substantially free of debris, rock, plant materials, and other foreign material larger than two (2) inches. The material will contain no sharp edges.
2. The top six (6) inches of the final cover system protective soil cover must be capable of supporting the growth of grass. The soils noted in 13.B.1.a. can be expanded to include SM and SP soils in the top six (6) inches of cover.

C. STOCKPILING AND MATERIAL APPROVAL

1. All material to be used as final cover system protective soil cover will be approved in advance by the CQC Engineer. The CQC Engineer must verify the soil meets all the material requirements.
2. Verification can be accomplished during excavation and stockpiling or prior to use at existing stockpiles.
3. The CQC Engineer will prepare reports of all testing, analysis, and verification.

D. CONSTRUCTION

1. The CQC Engineer will provide verification of the following information:
 - a. The approved stockpiled material was used to construct the final cover system protective soil cover.

- b. The final cover system protective soil cover was constructed in accordance with this CQA Plan.
 - c. The geomembrane and GDM were not damaged during the construction of the final cover system protective soil cover.
 - d. The final cover system protective soil cover thickness has been achieved and verified.
2. The final cover system protective cover material will be spread and compacted using low ground pressure equipment such as a CAT D6 low ground pressure (LGP) bulldozer or similar equipment.
 3. Material will be spread by pushing “up-slope”, and the CQC Engineer will verify that the protective soil cover was not pushed down any side slopes of the landfill final cover system.
 4. The final cover system protective soil cover material thickness will be at least 12 inches thick at all times during spreading and compaction.

E. SAMPLING AND TESTING

Construction quality assurance testing will meet the minimum requirements listed in the table below.

Final Cover System Protective Soil Cover Quality Assurance Testing Requirements			
Item	Test Method	Minimum Frequency	Minimum Criteria
Borrow Source	Grain Size ASTM D422 with Hydrometer	5,000 cy	See Note ⁽¹⁾ below
	Atterberg Limits ASTM D4318	5,000 cy	
	Moisture – Density ASTM D698	5,000 cy	7.5x10 ⁻⁵ cm/sec or less
	Remolded Permeability ⁽²⁾ ASTM D5084	10,000 cy	
Construction	Density and Moisture (ASTM D6938, 1556, or 2937)	1 test/20,000 ft ² of planar final cover system surface area	90% of Maximum Dry Density and 0% to 2% of the Optimum Moisture Content per ASTM 698 – Standard Proctor Test

Notes:

- ⁽¹⁾ Acceptable soils include those classified according to the Unified Soil Classification System (USCS) as SC, ML or CL (ASTM 02487). Liquid limit, plasticity index (PI), and gradation will be considered for proper classification.
- ⁽²⁾ Remold sample to 90% of Maximum Dry Density and 0% to 2% of the Optimum Moisture Content per ASTM 698 – Standard Proctor Test.

14. CERTIFICATION

The CQA Engineer will provide, within 30 days of completion of cell construction or closure activities, written certification that the liner and leachate collection system, final cover, access roads, ditches, sediment ponds, and other associated ancillary facilities for the particular landfill area were constructed according to the approved permit plans, technical specifications, and this CQA Plan. Said certification will have the CQA Engineer's seal as a professional engineer registered in the State of Georgia.