MONTEZUMA COUNTY LANDFILL

CONSTRUCTION QUALITY ASSURANCE PLAN

LINER, LEACHATE COLLECTION, & FINAL COVER SYSTEMS

REVISION 2

PREPARED FOR

MONTEZUMA COUNTY LANDFILL

March 26, 2024

Original Plan – May 27, 2016
Revision 1 – April 29, 2020
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1 INTRODUCTION

This Liner, Leachate Collection, & Final Cover Systems Construction Quality Assurance Plan (CQA Plan) for the Montezuma County Landfill (MCLF), in Cortez, Colorado, has been prepared to guide construction of the liner system, leachate collection system (LCS), and the final cover system. The MCLF Engineering Design and Operations Plan, Revision 2 (EDOP) provides the details of the design and operation of these systems. The MCLF is owned and operated by Montezuma County.

1.1 Purpose

This CQA Plan defines the quality assurance (QA) activities that will accompany construction to ensure the following:

- Liner system, leachate collection and recovery system (LCRS), and final cover system components are constructed in accordance with the EDOP;
- Required testing is conducted to verify components meet quality standards; and
- Records are produced and maintained to enable the production of the construction quality assurance (CQA) report to satisfy regulatory requirements.

Guidance, established by the Colorado Department of Public Health and Environment (CDPHE), pertaining to installation and verification of the liner system, LCRS, and final cover was incorporated into this CQA Plan.

This CQA Plan was developed to specify how materials used to construct the landfill components will be manufactured, installed, and tested to verify that they meet design criteria established in the EDOP. Details pertaining to where design components will be installed are included in the EDOP. The specifics of the incremental landfill cell development are provided in the construction documents.

2 PERSONNEL QUALIFICATIONS AND RESPONSIBILITIES

The qualifications and training required for CQA personnel, and the roles and responsibilities of the parties involved in constructing the landfill components are discussed in the following sections.

2.1 Project Meetings

Project meeting for CQA construction projects shall be held at the discretion of the owner. The intent of the meetings is to ensure communication between organizations involved in the construction of the MCLF.

2.2 Personnel Qualifications and Training

The qualifications and training required for CQA personnel are described in the following sections.

2.2.1 CQA Engineer

The CQA Engineer shall have landfill construction certification experience and be registered in the State of Colorado as a professional engineer. The CQA Engineer will certify the CQA report that is submitted to CDPHE following construction activities.

2.2.2 CQA Monitor

The CQA Monitor will have at least 1 year of experience conducting CQA monitoring for earthworks and liner installation, or a Bachelor of Science degree from a 4-year college or university in a degree program deemed relevant by the CQA Engineer. The CQA Monitor will collect samples, oversee construction, and prepare documentation.

2.2.3 CQA Surveyor

The CQA Surveyor must be, or work under the direct supervision of, a Professional Land Surveyor (PLS) registered in the State of Colorado. All record drawings need to be sealed by the PLS. The CQA Surveyor will collect as-built elevation data during construction.

2.2.4 Owner

The owner, Montezuma County, may conduct various aspects of the construction of the landfill components, which will generally include material procurement, earthworks, soil and LCRS material placement, final cover placement, geotextile fabric installation, and protective layer placement.

2.2.5 Geosynthetics Manufacturer

The geosynthetics manufacturers will be hired by the general contractor to furnish the geosynthetics required for the construction of Cell 5 including the HDPE geomembrane, the GCL, and the geotextiles. This plan includes specific quality assurance and quality control (QC) requirements for the geosynthetic manufacturers in their role of providing the QC during geosynthetic manufacturing.

2.2.6 Design Engineer

The Design Engineer is the company hired by the Owner to prepare the Engineering Design and Operations Plan. This Plan is prepared under the supervision of, and is sealed by, a Colorado registered professional engineer.

2.2.7 Facility Operator

Montezuma County is the facility operator.

2.2.8 General Contractor

The General Contractor will have overall responsibility for the completion of closure construction tasks at the landfill facility. The General Contractor will also be responsible for hiring all subcontractors.

2.2.9 Soils Testing Laboratory

The Soils Laboratory is an independent qualified laboratory hired by the Owner or CQA Engineer
to perform laboratory QA/QC soils tests as indicated in the CQA Plan. The Soils Laboratory will supply technicians, as necessary, for collection and laboratory analyses of samples. The QA/QC testing performed by the Soils Laboratory shall be performed under the supervision of a Colorado registered professional engineer.

2.2.10 Synthetic Liner Installer

The synthetic liner will be installed by an International Association of Geosynthetic Installers (IAGI) certified liner installer, who will prepare field sample seams, collect destructive liner samples, and conduct non-destructive seam testing.

3 PRE-CONSTRUCTION MATERIAL TESTING

3.1 General

Pre-construction material testing is intended to verify that the products needed for installation can meet the required material performance requirements. Additionally, pre-construction soil testing will be conducted to aid in soil liner selection and to determine a target range of moisture and dry density that increases the likelihood that permeability testing of completed clay liner system (CLS) results in passing values.

3.2 Structural Fill Testing

Pre-construction testing conducted on the soil to be used as structural fill during construction will confirm that the soil from the borrow source is suitable to be used for that purpose.

Pre-Construction Material Testing
Structural Fill

Phase	Material	Test and ASTM Number	Frequency	Required Value
Pre-Construction	Soil	Laboratory Standard Proctor Curve (D698)	1 per 10,000 cy	--
		Atterberg Limits (D4318)	1 per 10,000 cy	--
		Natural Moisture Content (D2216)	1 per 10,000 cy	--
		Particle Size Analysis (ASTM D7928/6913)	1 per 10,000 cy	Maximum of 2-inches
		USCS Classification (ASTM D2487)	1 per 10,000 cy	SM, SC, ML, CL, MH, CH

3.3 Clay Liner Classification Testing

Pre-construction testing conducted on the soil to be used in the low permeability CLS will confirm that the soil from the borrow source is suitable to be used for that purpose. The pre-construction testing will also establish target soil placed properties to archive the required hydraulic conductivity.

Pre-Construction Material Testing
Soil Liner

Test	Frequency	Required Result
Water Content (ASTM D2216)	1 per 5,000 cy	N/A
Atterberg Limits (ASTM D4318)	1 per 5,000 cy	CL/CH
Particle Size Analysis (ASTM D7928/6913)	1 per 5,000 cy	N/A
Laboratory Standard Proctor Curve (ASTM D698)	1 per 5,000 cy	N/A
Hydraulic Conductivity - remodeled (ASTM D5084)	1 per 10,000 cy	$1x10^{-7}$ cm/sec

3.4 Synthetic Liner Manufacturer's Quality Control

The pre-construction testing of synthetic liner material focuses on the information provided by the manufacturer (i.e., manufacturer's quality control (MQC)). The synthetic liner MQC information is provided by the manufacturer and reviewed by the CQA Monitor to verify that the material provided to construct the liner meets or exceeds the specifications for the liner. Synthetic liner specifications are based on 60-mil thick, high-density polyethylene (HDPE).

MQC Testing Requirements – Synthetic Liner

Properties	Test Method	Manufacturer QC Test Freq.	Required Test Values*
Thickness (min)	ASTM D5994	1 per Roll	54 mil (lowest individual for 8 of 10) 51 mil (lowest of any 10)
Asperity Height (min. avg.)	ASTM D7466	1 per 2 rolls	20 mil
Sheet Density (min)	ASTM D792 or ASTM D1505	1 per 200,000 lbs	0.940 g/cc
Tensile Properties (min. avg.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693	1 per 20,000 lbs	 126 lb/in 90 lb/in 12% 100%
Tear Resistance (min. avg.)	ASTM D1004 Die C	1 per 45,000 sf	42 lbs
Puncture Resistance (min. avg.)	ASTM D4833	1 per 45,000 sf	90 lbs
Stress Crack Resistance	ASTM D5397 (App.)	1 per 400,000 lbs	500 hours
Carbon Black Content (range)	ASTM D4218	1 per 20,000 lbs	2-3%
Carbon Black Dispersion	ASTM D5596	1 per 45,000 lbs	9 of 10 in categories 1 or 2
Oxidative Induction Time (OIT) (min. avg.) • Std. OIT, or • High Pressure OIT	 ASTM D3895 ASTM D5885	1 per 200,000 lbs	 100 min 400 min
Oven Aging at 85 C • Std OIT (min. avg.), or • High Pressure OIT (min.avg.),	ASTM D5721 ASTM D3895 ASTM D5885	1 per 200,000 lbs	 55% retained after 90 days 80% retained after 90 days
UV Resistance • High Pressure OIT (min. avg.) %	ASTM D7238	1 per 200,000 lbs	50% retained after 1600 hrs

Notes: * Required values can change if published by the Geosynthetic Research Institute via the test method GM 13, with the exception of asperity height.
QC = quality control min = minimum min.avg.= minimum average sf = square feet
mil = thousandth of an inch lbs = pounds lb/in = pounds per inch
g/cc = grams per cubic centimeter hrs = hours

MQC Testing Requirements – GCL

Properties	ASTM Test Method	Manufacturer QC Test Frequency	Required Test Values*
BENTONITE			
Swell Index	ASTM D5890	1 per 100,000 lbs	24 ml/2g min.
Moisture Content	ASTM D4643	1 per 100,000 lbs	12% max.
Fluid Loss	ASTM D5891	1 per 100,000 lbs	18 mil max.
FINISHED GCL			
Bentonite Mass Per Unit Area	ASTM D5261	1 per 50,000 sf	0.90 lbs/sf MARV
Grab Strength	ASTM D4362	1 per 50,000 sf	95 lbs MARV
Grab Elongation	ASTM D4632	1 per 50,000 sf	75% Typical
Peel Strength	ASTM D4632	1 per 50,000 sf	15 lbs. min.
Permeability*	ASTM D5084	1 per 100,000 sf	$5x10^{-9}$ cm/sec max
Internal Interface Shear	ASTM 5321	1 per lot	C=440 psf

Notes: * Required values can change if published by the Geosynthetic Research Institute via the test method GM 13, with the exception of asperity height.
QC = quality control lbs = pounds ml/2g = milliliters per 2 grams min = minimum
max = maximum sf = square feet lb/sf = pounds per square feet
MARV = minimum average roll value cm/sec = centimeters per second
psf = pounds per square feet

3.5 Geomembrane and Geosynthetic Clay-Receiving Inspection and Conformance Testing

The CQA Monitor shall perform receiving inspection on geomembrane and geosynthetic clay liner (GCL) material, and confirm that transportation, handling, and storage of geomembrane are performed in accordance with the specifications and manufacturer's instructions, as well as determine the condition of geomembrane rolls upon delivery to the site.

The CQA Monitor shall remove samples to be tested to determine conformance to the design specifications and the manufacturer's specifications. Samples may also be taken at the manufacturing facility.

Conformance Testing – Geomembrane

Properties	Test Method	Conformation QC Test Freq.	Required Test Values*
Thickness (min)	ASTM D5994	1 per 100,000 sf or per lot	54 mil (lowest individual for 8 of 10) 51 mil (lowest of any 10)
Asperity Height (min. avg.)	ASTM D7466	1 per 100,000 sf or per lot	20 mil
Sheet Density (min)	ASTM D792 or ASTM D1505	1 per 100,000 sf or per lot	0.940 g/cc
Tensile Properties (min.avg.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693	1 per 100,000 sf or per lot	 126 lb/in 90 lb/in 12% 100%

Notes: * Required values can change if published by the Geosynthetic Research Institute via the test method GM 13, with the exception of asperity height.
QC = quality control min = minimum sf = square feet min avg = minimum average
mil = millimeter g/cc = grams per cubic centimeter lb/in = pounds per inch lbs = pounds
hrs = hours

Conformance Testing – GCL

Properties	ASTM Test Method	Manufacturer QC Test Frequency	Required Test Values*
FINISHED GCL			
Bentonite Mass Per Unit Area	ASTM D5261	1 per 250,000 sf	0.90 lbs/sf MARV
Grab Strength	ASTM D4362	1 per 250,000 sf	95 lbs MARV
Grab Elongation	ASTM D4632	1 per 250,000 sf	75% Typical
Peel Strength	ASTM D4632	1 per 250,000 sf	15 lbs. min.
Permeability*	ASTM D5084	1 per 250,000 sf	$5x10^{-9}$ cm/sec max

Notes: * Required values can change if published by the Geosynthetic Research Institute via the test method GM 13, with the exception of asperity height.
QC = quality control lbs = pounds ml/2g = milliliters per 2 grams min = minimum
max = maximum sf = square feet lb/sf =pounds per square feet
MARV = minimum average roll value cm/sec = centimeters per second
psf = pounds per square feet

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

All GCL rolls shall be stockpiled and kept dry in a flat location area away from high-traffic areas but sufficiently close to the active work area to minimize handling.

GCL should be stored no higher than three to four rolls high or limited to the height at which the handling apparatus may be safely handled by installation personnel. Stacks or

tiers of rolls should be situated in a manner that prevents sliding or rolling by choking the bottom layer of rolls. The GCL rolls should remain in the manufacturer's packaging until the rolls are ready for deployment.

Rolls shall not be stacked on uneven or discontinuous surfaces in order to prevent bending, deformation, damage to the GCL, or cause difficulty inserting the core pipe.

Bagged bentonite material shall be stored and tarped next to GCL rolls unless other more protective measures are available. Bags shall be stored on pallets or other suitably dry surface that will prevent undue pre-hydration.

3.6 Drainage Layer Material Testing

The pre-construction testing of the drainage layer material is used to verify that the materials selected are suitable to be used for that purpose.

Preconstruction Material Testing
Aggregate

Properties (Test Method)	Frequency	Required Result
Grain Size Distribution (ASTM C136)	1 per 2,500 cy	<10% passing the 200 sieve
Permeability (ASTM D2434)	1 per 2,500 cy	$\geq 1x10^{-2}$ cm/sec
Carbonate Content (ASTM D4373)	1 per 2,500 cy	Less than 15%

Notes: cy = cubic yards cm/sec = centimeter per second

MQC Testing Requirements – Geotextile

Properties (Test Method)	Frequency	Required Result
Mass Per Unit Area	1 per 100,000 sf and minimum of 1 test per lot	8 oz/yd^2

Notes: sf = square feet oz/yd^2 = ounce per square yard

3.7 Final Cover Soil Classification Testing

Pre-construction testing of the water balance material is used to demonstrate that the soil has appropriate properties to be used as a water balance cover, which focuses on the soil's ability to store and release moisture and support vegetation. The measured soil texture is referenced to CDPHE's Water Balance Cover Acceptance Zone for Colorado Ecozone 1, provided below.

3.7.1 Final Cover Soil Classification Testing

The pre-construction testing conducted on the soil to be used in the final cover layer will confirm that the soil from the borrow source is suitable to be used for that purpose.

Pre-Construction Material Testing
Final Cover Soil

Test	Frequency	Required Result
Water Content (ASTM D2216)	1 per 2,000 cy	N/A(1)
Atterberg Limits (ASTM D4318)	1 per 5,000 cy	N/A(1)
Particle Size Analysis (ASTM D7928/6913)	1 per 5,000 cy	N/A(1)
Laboratory Standard Proctor Curve (ASTM D698)	1 per 5,000 cy	N/A(1)

Notes: cy = cubic yards N/A = not applicable

(1) The borrow material for final cover construction shall fall within the USDA textural triangle for Ecozone 1 as defined in the Final Guidance Document-Water Balance Covers in Colorado dated March 2013.

Pre-Construction Material Testing
Vegetative Layer

Properties (Test Method)	Frequency	Required Result
pH (EPA Method SW-846 SW 9045C)	1 per 6,500 cy	6.0 - 8.4
$CaCO_3$ (USDA Handbook Number 60)	1 per 6,500 cy	Less than 15%

Notes: cy = cubic yards

4 SUBGRADE AND SITE PREPARATION

4.1 General

The MCLF soil liner subgrade is primarily constructed through excavation, with the exception of the berms along the eastern and western edges of the landfill footprint, which requires the placement of structural fill. Observations made by the CQA Monitor shall be recorded on daily field monitoring forms, drawings, and test data forms. Sample frequency assumes a 1-foot thick subgrade material in excavation areas.

4.2 Earthworks

4.2.1 Excavation

During excavation, CQA personnel shall generally observe the excavated material and subgrade conditions and shall perform the following activities:

- Periodically observe stripping and excavation to document that there are no moisture seeps and that soft, organic, and otherwise undesirable materials are removed.
- Coordinate with the Contractor to confirm that the depth and slope of the excavations, sumps, surface water drainage ditches, and other construction components meet design requirements.

4.2.2 Fill

Prior to placement of any structural backfill, or compacted soil liner, CQA personnel will verify that the subgrade has been prepared (scarified, moisture-conditioned, and compacted) in accordance with the requirements of the specifications. Prior to filling, CQA personnel shall test the subgrade with in-place density methods. Nuclear density methods may be used (e.g., American Society for Testing and Materials (ASTM) D2922), or as approved by the designer.

During structural fill or compacted soil liner placement, CQA personnel will conduct tests and observations to document that the quality of compacted fill meets project specifications. This will include visual observation, measurement of lift thickness, verifying grain size analysis, determining moisture-compaction characteristics, and measuring in-place density and moisture content and other tests. Loose lift thickness shall not exceed 9 inches. Field in-place density tests shall be conducted at a frequency listed in this section. Additional tests may be conducted at the discretion of the CQA Engineer.

Subgrade preparation shall be observed by CQA personnel for compliance with the specifications. On the floor of the cell, the subgrade shall be compacted to at least 95%

of standard Proctor dry density (ASTM D698), and at the frequency listed in the table below. Compaction and testing will be required if fill is required to bring the subgrade elevations up to design grades.

Subgrade Material Testing Requirements

Properties (Test Method)	Frequency	Required Result
Standard Proctor Curve (ASTM D698)	1 per material type	N/A
Atterberg Limits (ASTM D4318)	1 per material type	N/A
Particle Size Analysis (ASTM D7928 with hydrometer)	1 per material type	N/A
In-Situ Compaction and Water Content Testing (ASTM D6938)	1 per 750 cy	95% or greater of Standard Proctor Maximum Dry Density (SPMDD) +/- 2% of optimum moisture content

Notes: N/A = not applicable cy = cubic yards

4.3 Stormwater Controls

Stormwater controls will be installed, as shown in the construction drawings. Stormwater from outside the landfill footprint should be kept out of the active construction area through run-on control features.

4.4 Survey Requirements

The subgrade will be prepared to the lines and grades shown in the construction drawings. The horizontal survey tolerance for this layer shall be 0.0 feet to 0.2 feet, in relation to the design elevations. The vertical survey tolerance for this layer shall be -0.2 feet to 0.0 feet, in relation to the design elevations. The subgrade will be surveyed on a grid spacing of 50-feet or less and at the tops and toes of slopes at a spacing of 50-feet or less.

5 LOW PERMEABILITY LINER CONSTRUCTION

5.1 General

The MCLF will use one of three proposed composite liner systems, depending on site conditions and location within the landfill footprint. One system will be comprised of 2 feet of compacted clay liner and a 60-mil HDPE geomembrane. The second will be comprised of 1 foot of compacted clay liner, a GCL, and a 60-mil HDPE geomembrane. The third will be comprised of 1 foot of compacted structural fill, a GCL, and a 60-mil HDPE geomembrane.

5.2 Compacted Clay Liner

The following section provides a description of the CQA activities required during placement of the clay liner portion of both composite liner system alternatives.

5.2.1 Soil Liner Material Testing

During placement of the compacted soil liner material, the moisture content and placed dry density will be measured. These measurements will be compared to the placement specifications in this CQA Plan. Areas not meeting the moisture or density requirements will be moisture conditioned and compacted or removed and replaced with suitable material. Moisture and density measurements will be conducted on each 6-inch compacted lift until the full design thickness is achieved.

The CQA monitor will also observe and document the following:

- Equipment is not disturbing the underlying layers as material is placed;
- Large clods will be removed or reduced in size prior to compaction;
- Significant water loss from the soil material is prevented through watering, covering, or other appropriate methods. Overbuilding the soil liner is considered a protective cover;
- At tie-in locations, any dry, cracked, or otherwise unsuitable areas of the existing soil are removed;
- Document the equipment type, configuration, and weight utilized for soil placement and compaction;
- Coverage by compaction equipment is uniform, especially at compacted fill edges, in equipment turnaround areas, and at the tops and bottoms of slopes;
- The specified soil density, water content, and permeability throughout each completed lift is achieved. This will be determined by laboratory and field testing;

- Repaired sections are tied-in with undisturbed sections of the liner, if necessary;
- Compacted lifts are tied together by scarifying the top of each lift, if necessary, with appropriate equipment prior to applying the following lift; and
- Newly placed material is thoroughly kneaded into existing material at tie-in locations.
- Removal of frozen/unacceptable materials
- Placement of material during freezing weather
- Compaction equipment that will be used for clay liner placement
- Loose lift thickness
- Methodology for tying into previously constructed cells

Soil classification testing is intended to build the relationship between the moisture content and dry density field measurements to the resulting hydraulic conductivity measure in the laboratory. The line of optimums will be used to define the placement moisture content and density requirements.

Required Material Testing – Clay Liner

Properties (Test Method)	Frequency	Required Result
In-situ Density and Moisture Content (ASTM D6938)	1 per 500 cy	Min of 95% of max dry density of standard Proctor
Moisture Content (ASTM D2216)	1 per 2,000 cy	N/A (Refer to the degree of saturation requirements below)
Grain Size Analysis (ASTM D7928 with hydrometer)	1 per 1,000 cy	P200 Content > 50% by weight
Standard Proctor Curve (ASTM D698)	1 per 5,000 cy or change in material type	N/A
Modified Proctor Curve (ASTM 1557)	1 per 5,000 cy or change in material type	N/A
Atterberg Limits (ASTM D4318)	1 per 5,000 cy or change in material type	CL/CH LL > 25% PI > 10%
Specific Gravity (ASTM D854)	1 per material type	N/A
Hydraulic Conductivity In Place (ASTM D5084)	1 per 5,000 cy or 1 per lift (whichever yields a larger number)	≤1.0 x 10^{-7} cm/sec

Notes: cy = cubic yards min = minimum max = maximum cm/sec = centimeters per second

Line of Optimum Method

The compacted soil layer shall be moisture conditioned so that at least 80% of the moisture tests indicate a moisture content wet of optimum moisture. All moisture tests

will achieve minimum moisture corresponding to 75% saturation. The use of the standard and modified Proctor curves will be used to generate an acceptable zone for use with the in-situ measurements of moisture and density. In-situ measurements of density and moisture will be conducted with a moisture/density gauge to determine if the compacted soil material is within the acceptable zone for moisture and density.

Voids created during the use of the moisture/density gauge or in-situ hydraulic conductivity sampling shall be backfilled with granular bentonite.

5.3 Composite GCL Liners

5.3.1 Composite GCL Liner- Clay

Shelby tube samples of the in place soil liner shall be obtained at a minimum frequency, as listed for hydraulic conductivity in Section 5.2.1 of this CQA Plan, for material placed. At any time, additional samples may be obtained at the discretion of the CQA Engineer.

In some instances, a composite liner that includes a GCL layer may be preferred for the landfill liner system. The composite liner consists of a 1-foot compacted soil layer, a GCL layer, and a 60-mil HDPE geomembrane. The CQA requirements for the composite liner's compacted clay liner layer are identical to that shown in Section 5.2.

Sections 5.3.3 through 5.4.7, provide a description of the CQA activities required during placement of the geosynthetic clay component of the composite liner.

5.3.2 Composite GCL Liner -Structural Fill

Structural fill materials shall be from on-site soils derived from the cell excavation or other on-site borrow areas that consist of relatively homogeneous, well-graded, natural soils that are free of debris, foreign objects, large rock fragments, roots, and organic material. No materials greater than 2 inches shall be allowed. The structural fill for the composite GCL liner shall be removed to line and grade of the shown on the excavation points layout drawing in the construction drawings and replaced in 6-inch compacted lifts (8-inch maximum loose lifts) to the line and grade shown on the structural fill points layout drawing in the construction drawings.

Required Material Testing – Structural fill Liner

Properties (Test Method)	Frequency	Required Result
In-situ Density and Moisture Content (ASTM D6938)	1 per 500 cy	Min of 95% of max dry density of standard Proctor and +/- 2% of optimum moisture content.
Moisture Content (ASTM D2216)	1 per 2,000 cy	+/- 2% of optimum
Grain Size Analysis (ASTM D7928 with hydrometer)	1 per 5,000 cy	N/A

Properties (Test Method)	Frequency	Required Result
Standard Proctor Curve (ASTM D698)	1 per 5,000 cy or change in material type	N/A
Atterberg Limits (ASTM D4318)	1 per 5,000 cy or change in material type	N/A
USCS Classification (ASTM D2487)	1 per 5,000 cy or change in material type	SM, SC, ML, CL, MH, CH

Notes: cy = cubic yards min = minimum max = maximum cm/sec = centimeters per second

Sections 5.3.3 through 5.4.7, provide a description of the CQA activities required during placement of the geosynthetic clay component of the composite liner.

5.3.3 Geosynthetic Clay Liner Panel Placement

The CQA Monitor shall confirm that the surface upon which the GCL will be installed is suitably prepared and will not damage the GCL. GCL shall not be deployed in quantities greater than what can be covered with geomembrane by the end of the working day, unless otherwise approved by the CQA Engineer. The surface that the GCL is deployed over shall be free of clods, rocks, sticks, sharp changes in grade, ruts greater than 1 inch in length, desiccation cracks, and standing water. Where the bedding surface is the low permeability liner, methods shall be taken to prevent the soil liner surface from drying and cracking prior to installing the GCL. These methods may include the use of a temporary cover.

The GCL installer shall inspect and provide written certification to the owner or CQA Engineer that the prepared surface under consideration is suitable for installation of the geomembrane.

Panels of GCL will be joined together as described in Section 5.3.2 after they are placed in the landfill to form a continuous moisture barrier. The CQA Monitor shall document that the placement and seaming activities are performed as specified in this CQA Plan.

On slopes or grades steeper than 10%, seams shall be oriented down and not across the slope. No horizontal seam shall be less than 5 feet from the top of the slope or other area of potential stress concentration. Seams shall not line up with leachate piping runs. The number of field seams shall be minimized in areas such as corners and odd-shaped geometric locations. In anchor trenches, the GCL shall be continuous through the trench, over the crest, and down the slope.

Placement shall not be attempted in rain, snow, or under conditions of excessive fog or dew. Placement will not be permitted in areas of ponded water or in the presence of excessive winds.

Equipment used for placement shall not damage the GCL or the subgrade by handling, trafficking, leakage of hydrocarbons, or in other ways. Personnel working on the GCL shall not engage in any activities or wear footwear that could damage the GCL. Direct contact

of any heavy mechanical equipment with the GCL shall not be allowed.

Panels shall be carefully unrolled according to the manufacturer and fabricator's instructions, and in a manner that does not scratch or crimp the geomembrane. Panels shall be aligned to minimize wrinkles or fish mouths, especially along the field seams. Adequate precautions, such as placement of sand bags, shall be taken to minimize the likelihood of wind uplift.

5.3.4 Joining

The GCL shall be joined, as described below:

- Adjacent sections of GCL shall be overlapped, according to the manufacturer's directions.
- Overlaps shall be free of wrinkles, folds, or more importantly fish mouths.
- Overlap seams shall be a minimum of 12 inches on panel edges and 24 inches on panel ends or as otherwise provided by the manufacturer.
- Loose granular bentonite should be placed between panels at a rate of ¼ pound per lineal foot of seam if the GCL is the primary hydraulic seal, or as otherwise provided by the manufacturer.
- No horizontal seams shall be allowed on sideslopes provided rolls can be manufactured to sufficient length. If required because of manufacturing limitation end seams shall be staggered.
- If more than one layer of GCL is installed, joints shall be staggered.
- Rips or tears may be repaired by completely exposing the affected area, removing all foreign objects or soil, and by then placing a patch cut from unused GCL over the damage (damaged material may be left in place), with a minimum overlap of 12 inches on all edges.
- Accessory bentonite should be placed between the patch edges and the repaired material at a rate of a quarter pound per lineal foot of edge spread in a continuous 6-inch fillet.

5.3.5 Materials in Contact with GCL

The requirements of this section are intended only to minimize the risk of GCL damage during installation on existing surfaces or during placement of overlying materials. The installer shall not perform any cutting, testing, or work on top of the GCL.

The installer, with prior approval from the owner, may elect to use a remnant piece of geosynthetic material as a temporary "rub-sheet" beneath the GCL to act as a cushion during panel deployment.

Installation of the overlying geosynthetic component can be accomplished through the use of lightweight, rubber-tired equipment such as a 4-wheel all-terrain vehicle (ATV) or pickup truck/all-terrain forklift. This vehicle can be driven directly on the GCL, provided the ATV/truck/forklift makes no sudden stops, starts, or turns.

Equipment used for placing and compacting overlying soil materials shall not be driven directly on to any geosynthetic material. No sharp turning of the spreading equipment will be allowed on the initial 12 inches of cover. No heavy rubber-tired vehicles shall be allowed in areas underlain by GCL until a minimum of 3 feet of cover material has been placed. Equipment shall be observed by the CQA Monitor during placement to document that no leakage of hydrocarbons occurs, particularly on top of the GCL.

Placement of soil materials on top of the GCL shall not be allowed within 50 feet of any unseamed edge of GCL until field seaming of that edge is complete. This is required to allow sufficient room to work out any large wrinkles or fish mouths prior to seaming.

The placement of cover materials shall be done with caution and in a manner that is least likely to cause wrinkles in, or damage to, the GCL. The CQA Monitor shall observe the placement of cover materials over the GCL on a regular basis.

5.4 Geomembrane Panel Placement

The following text and sections provide a description of the CQA activities required during placement of the geomembrane component of both composite liner systems.

The CQA Monitor shall confirm that the surface upon which the geomembrane will be installed is suitably prepared and will not damage the geomembrane. The geomembrane bedding layer shall be free of clods, rocks, sticks, sharp changes in grade, ruts greater than 1 inch in length, desiccation cracks, and standing water. Where the bedding surface is the low permeability liner, methods shall be taken to prevent the soil liner surface from drying and cracking prior to installing the geomembrane. These methods may include the use of a temporary cover.

The geomembrane installer shall inspect and provide written certification to the owner or CQA Engineer that the prepared surface under consideration is suitable for installation of the geomembrane.

Sheets of geomembrane will be welded together after they are placed in the landfill to form a continuous moisture barrier. The CQA Monitor shall document that the placement and seaming activities are performed as specified in this CQA Plan. Seams or repaired areas that do not pass the tests shall be repaired and retested until a passing result is achieved.

Each field panel and field seam shall be given an identification code that is consistent with the proposed sequence of installation. A field panel is defined as the area of geomembrane that is to be cut and seamed in the field by the installer.

On slopes or grades steeper than 10%, seams shall be oriented down and not across the slope. No horizontal seam shall be less than 5 feet from the top of the slope or other area of potential stress concentration. Seams shall not line up with leachate piping runs. The number of field seams shall be minimized in areas such as corners and odd-shaped geometric locations. In anchor trenches, the geomembrane shall be continuous through the trench, over the crest, and down the slope.

Geomembrane shall not be placed when ambient temperatures are less than 32 °F or more than 104 °F, measured 12 inches above the geomembrane. Placement shall not be attempted in rain, snow, or under conditions of excessive fog or dew. Placement will not be permitted in areas of ponded water or in the presence of excessive winds.

Equipment used for placement shall not damage the geomembrane or the subgrade by handling, trafficking, leakage of hydrocarbons, or in other ways. Personnel working on the geomembrane shall not engage in any activities or wear footwear that could damage the geomembrane. Direct contact of any heavy mechanical equipment with the geomembrane shall not be allowed.

Panels shall be carefully unrolled according to the manufacturer and fabricator's instructions, and in a manner that does not scratch or crimp the geomembrane. Panels shall be aligned to minimize wrinkles or fish mouths, especially along the field seams. Adequate precautions, such as placement of sand bags, shall be taken to minimize the likelihood of wind uplift.

5.4.1 Geomembrane Field Seaming

General

Approved seaming methods are extrusion welding and single or dual track fusion welding. Fusion welding shall be utilized for tie-in seams between existing and new geomembrane.

Seaming shall be a continuous process with a minimum of interruptions along any given seam. The installer shall maintain at least two operable spare seaming units onsite.

Where conditions warrant, the installer may be allowed to use a temporary support surface between the geomembrane and the subgrade to achieve proper support conditions during seaming operations. The use of such support methods shall be subject to the approval of the CQA Engineer. The support shall not be left in-place and shall be removed on completion of seaming.

Wherever possible, wrinkles or fish mouths shall be pulled out of the overlap area prior to seaming. Where this cannot be done, they shall be cut along the ridge of the wrinkle in order to achieve a flat surface. Such cuts shall be seamed. Where the overlap is inadequate, an oval or round patch of the same geomembrane, extending a minimum of 6 inches beyond the cut in all directions, shall be seamed onto the geomembrane.

Required Testing During Installation – Geomembrane

Properties (Test Method)	Frequency	Required Result
Seam Overlap	Every Panel	3-inch for extrusion 5-inch for fusion
Trial Seam (ASTM 6392)	1 trail seam every 4 hours per welding machine	Follow section 5.4.1 requirements
Vacuum Test (ASTM D5641)	All extrusion welds or single wedge fusion welds	No Bubbles
Air Pressure Test (ASTM D5820)	All double wedge fusion welds	Less than 2 psi drop over 5 minutes

Extrusion Welding Process

The extrusion welding apparatus shall be equipped with gauges to measure the temperature at the nozzle or the preheat temperature of the apparatus. The CQA Monitor shall verify the extrudate and ambient temperature at appropriate intervals. The extruder shall be purged of heat-degraded extrudate at the beginning of each seaming sequence. The extrudate rod shall be dry and free of moisture before entering the apparatus. If there is moisture, the operator shall clean the extrudate rod before entering the apparatus.

Artificially induced cooling of extrudate welds (using water or any other means) shall not be allowed. Sufficient time between welding and non-destructive testing shall be taken so that non-destructive testing procedures do not cause artificial cooling of the extrudate.

Fusion Welding Process

Fusion welding apparatus shall be automated, self-propelled devices that produce either a single seam or a double seam with an enclosed central air space. The apparatus shall be equipped with gauges that indicate the equipment temperatures during welding. For the seaming of cross-seams, the top and bottom edges of the cross-seam shall be ground to a smooth incline prior to seaming.

The CQA monitor shall log ambient and seaming apparatus temperatures and seaming apparatus speed for each seam.

Seam Overlap and Preparation

Prior to seaming, geomembrane rolls or panels shall be overlapped by a minimum of 3 inches for extrusion welding and 5 inches for fusion welding or as recommended by the manufacturer. Procedures used to bond adjacent rolls together temporarily shall not result in damage to the geomembrane. If mechanical devices such as hot air leisters are used for temporary bonding, the air temperature at the nozzle of such equipment shall be controlled so as not to damage the geomembrane. Solvents or adhesives shall not be used.

Seams shall be aligned to create the smoothest surface as practicable with a minimum of wrinkles and fish mouths. The area in the immediate vicinity of the seam shall be free of moisture, dust, dirt, debris, or any other foreign material and, if necessary, sheltered from wind and dust immediately prior to and during the seaming operation. If grinding is required along the seam, this shall be done according to the manufacturer's recommendations, within 1 hour of the seaming operation and in a manner that does not damage the geomembrane. This process shall also include cleaning the seam area with a brush or forced air immediately prior to seaming. Particular care shall be paid to the condition of existing geomembrane prior to tie-in with new geomembrane.

The CQA Monitor shall document geomembrane seam overlaps and preparation procedures.

Weather Conditions

In general, seaming shall not be attempted when ambient temperatures are below 32 °F or above 104 °F, as measured 12 inches above the liner. Below 32 °F, seaming may be allowed, if suitable precautions are taken and the installer is able to certify in writing that seaming under these conditions will not cause any chemical or physical alteration to the geomembrane that may deleteriously affect its short- or long-term performance. Approval by the CQA Engineer will be required to seam with ambient temperatures that are below 32 °F or above 104 °F. Extrusion welding will require the geomembrane to be preheated by either the sun or the use of a hot air device, and the installer shall take precautions that excessive cooling resulting from wind does not affect the seaming

operation. The CQA Monitor shall determine when preheating is required and whether wind affects may be deleterious to seaming operations.

Seaming shall not be performed during wet weather where the geomembrane is exposed to the elements.

Trial Seams

Trial seams shall be made to verify that adequate conditions exist for field seaming to proceed. Each seamer shall produce a trial seam at the beginning of each shift. Additional trial seams shall be made every 4 hours or, if a breakdown of the seaming equipment occurs, prior to resumption of seaming operations. The CQA Monitor shall monitor and log the trial seam results.

Trial seams shall be made on pieces of geomembrane identical to the installed product measuring at least 2 feet long by 1 foot wide (after seaming) with the seam centered lengthwise and overlapped as required for the particular seaming process.

Six samples, each 1-inch wide, shall be cut from the test seam and tested, two in shear and four in peel, using a tensiometer calibrated within the past 6 months. The samples shall not fail in the seam. If a seam failure occurs, then a second seam shall be produced and tested. If a second failure results, the apparatus or seamer shall be rejected and shall not be used for field seaming until any deficiencies have been corrected. This shall be verified by the production and successful testing of two consecutive trial seams.

5.4.2 Geomembrane Non-Destructive Seam Testing

Seams shall be non-destructively tested by the installer over their full length to verify their continuity. It should be noted that this testing does not provide any information regarding seam strength. Non-destructive testing shall be performed concurrently with field seaming using the equipment and procedures described below. Any seam that fails the non-destructive test shall be repaired. Repairs shall be retested to determine the success of the repair.

Where the CQA Monitor has determined that seams cannot be non-destructively tested due to physical constraints, the seams shall be capped with the same geomembrane or double seamed. The CQA Monitor shall observe the seaming and capping of such seams to assess their adequacy and determine whether additional action is required. Where such a seam is accessible for testing prior to final geomembrane deployment, testing shall be performed prior to deployment.

All nondestructive testing shall be conducted by the installer and continuously observed by the CQA Monitor.

Vacuum Testing

For extrusion and single wedge fusion welded seams, seams shall be evaluated using vacuum box testing. The vacuum box shall consist of a rigid housing with a transparent viewing window on top and a soft, flexible gasket attached to the bottom of the housing. A porthole and valve assembly along with a calibrated vacuum gauge shall be provided at one end of the housing. The vacuum gauge shall be calibrated prior to initial use on the project and recalibrated on at least an annual basis, at the end of the project, or at the discretion of the CQA Engineer. The installer shall supply vacuum gauge calibrations to the CQA Engineer for review prior to the start of testing. A steel vacuum tank and pump assembly complete with the necessary pressure controls, pipe connections, pressure hoses, and fittings shall be provided. A soapy solution and a method of dispensing the solution are also required.

The tests shall be performed according to ASTM D5641. To perform the test, the pressure in the vacuum tank shall be reduced to approximately 5 inches of mercury. The soapy solution shall be applied to the test section and the vacuum box placed over the wetted area. The bleed valve shall then be closed and the vacuum valve opened. Once a tight seal has been established, the test section shall be visually examined for a period of not less than 10 seconds to determine whether bubbling of the soapy solution is occurring. The vacuum valve shall then be closed and the bleed valve opened. The vacuum box shall be removed and the process repeated on the next adjacent test section. A minimum 3-inch overlap shall be provided on test sections. Any locations where bubbling of the soapy solution is observed, shall be clearly marked for repairs. Repairs shall be retested.

Air Pressure Testing

This test method (ASTM D5820) shall apply only when the double hot wedge fusion seaming method is used to form the seam. The testing equipment shall consist of an air pump capable of generating and sustaining pressure of at least 40 pound-force per square inch (psi) complete with a pressure gauge and the necessary pressure hose, fittings, and connections. An approved pressure feed device, such as a sharp hollow needle, shall be provided to penetrate into the central air channel at one end of the seam. A second calibrated pressure gauge in 1 psi increments capable of reading pressures up to 40 psi shall be provided to detect any pressure loss at the opposite end of the seam from the pressure feed device.

To perform the test, a section of the seam shall be sealed off at both ends. The pressure feed device shall be inserted into the air channel at one end of the sealed section, and the second pressure gauge shall be inserted into the opposite end of the air channel. If the seam is ½-inch wide, it shall be pressurized to a minimum pressure of 30 psi. The pressure valve shall be closed and the pressure monitored for a period of not less than 5 minutes. If a pressure loss greater than 2 psi is observed at either end or if the required pressure cannot be reached, then the seam shall be rejected. If, in the judgment of the CQA personnel, significant changes in temperature occur during the test (e.g., due to

cloud cover), the test shall be repeated after the geomembrane has stabilized. Faulty areas along the seam shall be identified and repaired in accordance with Section 5.4.4. Holes created during non-destructive testing shall be repaired in accordance with Section 5.4.4.

5.4.3 Geomembrane Destructive Seam Testing

Destructive testing of field seams shall be performed at selected locations in order to verify the seams' strength. Seam destructive tests shall be performed at a minimum average of one test per 750 lineal foot per welder. Sampling and testing shall be done concurrently with field seaming operations so that corrective action, if required, may be implemented as the work progresses. Sample locations shall be determined by the CQA Monitor based on the required sampling frequency and seaming observations. The installer shall not be informed in advance of the locations where the seam samples will be taken. Additional test locations may be required during seaming operations, such as along tie-in seams with existing geomembranes. The necessity for such additional sampling and testing shall be determined by the CQA Monitor, and extra testing shall be performed when there is cause to suspect the presence of excess crystallinity, contamination, offset welds, or any other potential defect. The CQA Engineer may increase the minimum frequency of destructive testing as the work progresses based on the results of previous testing.

Samples shall be cut by the installer under the observation of the CQA Monitor. Each sample shall be numbered and identified. The sample number and location shall be recorded by the CQA personnel on the layout drawings to be included in the CQA Report.

The test sample shall measure approximately 12 inches wide by 42 inches long, with the seam centered lengthwise. Two 1-inch wide strips shall then be cut, one from either end of the sample. Both of these strips shall be tested by the installer in the field using a tensiometer to determine the mode of failure in both peel and shear. The remaining portion of the sample shall be cut into three equal parts having a minimum length of 12 inches. One sample shall be taken by the CQA Monitor for destructive testing under laboratory conditions. One sample shall be given to the installer to perform CQA testing. The third sample shall be kept in storage by the owner, if desired.

The area from which the test sample was cut shall be immediately repaired, as described in Section 5.4.4. Seams created for these repairs shall be non-destructively tested in accordance with Section 5.4.2.

Neither of the field tests shall fail in the seams. The results of the laboratory testing by the CQA Monitor shall determine the acceptability of the field seam.

A field seam shall only be considered acceptable when it is bounded by two destructive test locations that meet the seam strength requirements listed in the specifications, as

well as passing the non-destructive tests described in Section 5.4.2. Whenever a sample fails a destructive test, whether that test is conducted by field tensiometer, CQA laboratory, or the installer's laboratory, the following procedures shall be employed to remedy the failed seam section:

- The installer may cap the failing seam between any two passed test locations;
- The installer may elect to trace the seam to two intermediate locations a minimum of 10 feet in either direction from the point of the failed test and take a small sample for an additional field test at each location. If these additional samples pass the test, then full samples shall be taken for CQA laboratory testing. If these laboratory samples pass the tests, then the seam shall be capped between these locations. If either sample fails, the sampling and testing process shall be repeated to establish the zone over which the seam shall be capped; or
- Cap all seams welded by the machine that had the failing test.

The continuity of capped seams shall be verified by non-destructive testing in accordance with Section 5.4.2. In addition, if the total capped seam length exceeds 150 feet, a destructive sample shall be taken for laboratory testing, as described above.

The CQA Monitor shall document actions taken in conjunction with destructive test failures.

Required Geomembrane Seam Destructive Testing During Installation

Property	Qualifier	Unit	Specified Value[1]		Test Method
PHYSICAL PROPERTIES – HOT WEDGE SEAMS					
Shear Strength[1,2] (at yield point)	Minimum	lb/in width	120	FTB[2,3]	ASTM D6392
Peel Adhesion	Minimum	lb/in width	91	FTB	ASTM D6392
PHYSICAL PROPERTIES – EXTRUSION SEAMS					
Shear Strength[1,2] (at yield point)	Minimum	lb/in width	120	FTB[2,3]	ASTM D6392
Peel Adhesion[4]	Minimum	lb/in width	78	FTB	ASTM D6392

Notes: [1] Destructive testing shall meet specified values for all testing. Values from GRIGM-19
[2] Also called Bonded Seam Strength.
[3] FTB = Film Tear Bond (failure occurs through intact geomembrane, not through seam).
[4] No more than 25% of the seam width can separate (peel) to be considered a passing specimen.

5.4.4 Defects and Repairs

Any field panel or part of a field panel that becomes seriously damaged shall be replaced at the direction of the CQA Monitor. Minor damage, such as small wrinkles or crimps, shall be repaired. Damaged field panels that have been rejected for use shall be removed from the site.

The entire geomembrane surface shall be examined by the CQA Monitor in order to confirm that the geomembrane is free of any defects, holes, blisters, undispersed raw materials, or contamination by foreign matter. Particular attention shall be paid to existing geomembrane in tie-in areas. Whenever possible, the examination of the geomembrane surface shall be done prior to any seaming in that area. If necessary, the geomembrane surface shall be cleaned by the installer so that it is free of dust, mud, or any other materials that may inhibit a thorough examination of the surface. Any suspect areas shall be clearly marked by the CQA Monitor and non-destructively tested by the installer in accordance with Section 5.4.2. Any location that fails to pass the non-destructive testing, or where a destructive test sample has been removed, shall be repaired using one of the procedures described below.

Small tears, wrinkles, scratches, or pinholes shall be repaired by the installer using spot welding, seaming, or patching, as appropriate. Large holes and tears, undispersed raw materials, and any areas that have been contaminated by foreign matter shall be repaired by the installer using patches or by capping the area. All damage that fully penetrates the layers shall be repaired with a patch. Patches shall be round or oval in shape, shall consist of the same geomembrane material, and shall extend a minimum of 6 inches beyond the edge of the defect in all directions. Temporary bonding methods used to hold patches in-place prior to seaming shall not damage the geomembrane. Geomembrane surfaces to be patched shall be abraded in accordance with the specifications. Surfaces shall be clean and dry at the time the repair work is performed. Repair seaming shall follow the seaming procedures described in Section 5.4.1.

Repairs shall be non-destructively tested using the appropriate methods described in Section 5.4.2. Unless additional destructive testing is required, as described in Section 5.4.3, repairs that pass the non-destructive test shall be considered acceptable. Any repairs that fail the non-destructive test shall not be accepted, and the installer shall perform the necessary remedial work and retest the repaired area until it passes the non-destructive testing criteria.

Upon completion of field seaming and testing, and prior to any placement of materials on top of the geomembrane, the CQA Monitor shall identify any large wrinkles or fish mouths that may have been built into the geomembrane. Any such features shall be cut out, repaired, and tested by the installer.

In any given area, no work shall proceed with any materials that may cover the geomembrane until repairs in that area have been successfully made. As the work progresses, the CQA Monitor shall document locations requiring repair work and shall confirm that repairs have been successfully made.

Required Geomembrane Testing Following Repairs

Properties (Test Method)	Frequency	Required Result
Seam Overlap	Every Repair Seam	6-inch for all every seam
Vacuum Test (ASTM D5641)	All extrusion welds or single wedge Fusion welds	No Bubbles

5.4.5 Materials in Contact with Geomembrane

The requirements of this section are intended only to minimize the risk of geomembrane damage during placement of overlying materials. The installer shall not perform any cutting, testing, or work on top of the geomembrane. All generators shall be kept off the geomembrane.

The installer, with prior approval from the owner, may elect to use a remnant piece of geosynthetic material as a temporary rub-sheet beneath the geomembrane to act as a cushion during panel deployment.

Placement of materials on top of the geomembrane shall not be allowed when the ambient temperature is below 32 °F or above 104 °F.

Equipment used for placing and compacting overlying soil materials shall not be driven directly on to any geosynthetic material. A minimum thickness of 6 inches of material shall be maintained between the geomembrane and the low contact pressure bulldozer or light motor grader used to place cover materials. No sharp turning of the spreading equipment will be allowed on the initial 12 inches of cover. No heavy rubber-tired vehicles shall be allowed in areas underlain by geomembrane until a minimum of 3 feet of cover material has been placed, with the exception that a light grader may be used on the 6-inch cover for fine grading and trimming operations. However, the weight of the equipment may not exceed 5 psi, as measured on the geomembrane surface. Equipment shall be observed by the CQA Monitor during placement to document that no leakage of hydrocarbons occurs, particularly on top of the geomembrane.

Placement of soil materials on top of the geomembrane shall not be allowed within 50 feet of any unseamed edge of geomembrane until field seaming of that edge is complete. This is required to allow sufficient room to work out any large wrinkles or fish mouths prior to seaming.

The placement of cover materials shall be done with caution and in a manner that is least likely to cause wrinkles in, or damage to, the geomembrane.

5.4.6 Anchor Trench

The CQA Monitor will observe the anchor trench construction to ensure that the trench surface is suitably smoothed and that it will not damage the liner. The structural fill placed back on top of the liner will be placed as discussed in Section 4.2.2.

5.4.7 Survey Requirements

The liner will be prepared to the lines and grades shown in the construction documentation. The horizontal survey tolerance for this layer shall be 0.0 feet to 0.2 feet in relation to the design elevations. The vertical survey tolerance for this layer shall be 0.0 feet to 0.2 feet in relation to the design elevations. The top of liner will be surveyed on a grid spacing of 50-feet or less and at the tops and toes of slopes at a spacing of 50-feet or less.

6 DRAINAGE LAYER CONSTRUCTION

6.1 General

The CQA Monitor shall observe placement of the drainage material and shall confirm that the placed depth is at a minimum of 6 inches. Placement of drainage materials over geomembranes will follow the procedures of Section 5.4.5.

6.2 Sump Pipe Installation

The high-density polyethylene HDPE pipe network shall be placed according to the design. CQA monitoring activities shall include:

- Review of construction subcontractor's submittals concerning joining methods and type of perforations;
- Review of manufacturer's certification to document that the HDPE pipe meets the specifications;
- Observe and measure to confirm that the pipes are placed at specified locations and in specified configurations, and that pipe grades are as specified;
- Verify that the internal cleanliness of HDPE pipe is maintained;
- Visually observe that pipes are joined together and perforated in accordance with the approved procedures;
- Observe that the placement of any filter or backfill materials around the pipe proceeds, as shown on the plans;
- Witness, review, and document testing of HDPE piping prior to being buried or covered with liner; and
- Observe that backfilling and compaction are completed as specified and that, in the process, the pipe network is not damaged.

6.3 Aggregate Leachate Header

The stone drainage collection channel network shall be placed according to the design. CQA monitoring activities shall include:

- Testing the material to confirm that it has the specified particle size and is free from excessive amounts of fines or organic materials;
- Measuring the thickness and observing coverage of each drainage layer as it is placed in the LCS;

- Observe placement of geotextile as required;
- Observe and measure to confirm that the header are placed at specified locations and in specified configurations, and that header grades are as specified;
- Verify that the internal cleanliness of header is maintained;
- Observe that the placement of any filter or backfill materials around the header proceeds as shown in the construction documents; and
- Observe that backfilling and compaction are completed as specified and that, in the process, the header network is not damaged.

6.4 Leachate Collection Layer

The drainage material may be composed of sand/gravel or geocomposite. Inspection of the drainage layer shall include the following:

- Measuring the thickness of the drainage layer material either by survey or by direct measurement from the top of the material to the top of the underlying material;
- Observe placement of geotextile as required; and
- Confirm the horizontal survey tolerance for the drainage layer is 0.0 feet to 0.2 feet.

The following placement criteria will be used by the Contractor while installing the drainage layer if sand/gravel are to be used for drainage layer construction:

• During placement of the leachate drainage layer over the liner, at least 3 feet of granular soils shall be maintained between the earth-moving equipment and underlying liner except for during final spreading when a minimum of 1 foot separation shall be maintained. Final spreading of the leachate drainage layer shall be conducted using a low ground pressure (less than 5 psi) dozer approved by the CQA Engineer, and shall be performed in a manner that protects the underlying geosynthetics, i.e., no sharp turns, quick stops, etc.

• A minimum final thickness of 1 foot of drainage material will be placed over the floor liner.

• The CQA Engineer will observe the spreading and grading of the granular material and document that it meets the project specifications. This observation will also be conducted to detect potential and/or actual damage to the underlying geosynthetics upon which the material is being placed. Where damage is suspected, the underlying component surface will be exposed and observed to

determine its condition. Actual damage, as well as corrective action taken, will be documented.

6.5 Geocomposite Drainage Layers

Should a geocomposite be the chosen alternative for the drainage layer, a double-sided geocomposite with a 6 ounce per square yard (oz/yd^2) non-woven geotextile on both sides shall be used, and the following section shall be applied.

6.5.1 Pre-Construction

Prior to shipment of the rolls of geocomposite, the CQA Subcontractor will obtain samples at a frequency of one per production lot or one per 100,000 square feet of each material type, whichever results in the greater number of tests; except that only one friction angle tests on each interface will be performed. The CQA Subcontractor will test the samples to determine conformance to both the Technical Specifications and the list of certified properties.

Tests on the geonets and geotextiles that are intended for use for the geocomposite shall be performed prior to geocomposite fabrication. Geotextiles shall be tested in accordance with requirements for geotextile.

The following tests will be performed on geonets, at a minimum:

- Polymer specific gravity (ASTM D1505)
- Thickness (ASTM D5199)
- Mass per unit area (ASTM D5261)

The following tests will be performed on geocomposites, at a minimum:

- Ply Adhesion (ASTM D7005)
- Transmissivity (ASTM D4716)

6.5.2 Construction

Materials and work that fail to meet the requirements of these specifications shall be removed, disposed of, and replaced at the Subcontractor's expense.

6.5.3 Installation Plan

The Subcontractor shall submit a plan describing the proposed methods for geocomposite unloading, storage, deployment, panel layout, seaming, testing, repair, and protection. The plan shall include a QA program (training, qualifications, procedures, records,

oversight/peer review, etc.) for the Subcontractor's activities, related to geocomposite installation.

6.5.4 Handling and Placement

The geocomposites shall be handled and placed, as described below:

- The Subcontractor shall handle geocomposites in such a manner as to ensure that these materials are not damaged.
- Clean geomembrane surface prior to placing geocomposite to remove dust, dirt, and debris.
- On slopes, geocomposite may be deployed over slip-sheets with the roll at the top of the slope. An alternative method is to secure the geocomposite, then roll it down slope in a manner to continually keep it in tension, if necessary, position the geocomposite after deployment to minimize wrinkles, and remove the slip-sheet, if used.
- Do not drag the geocomposite across textured geomembrane.
- In the presence of wind, exposed geocomposites shall be weighted with ultraviolet (UV) resistant sandbags, or equivalent. Sandbags shall be installed during geocomposite placement and shall remain until replaced with cover material.
- Unless otherwise specified, geocomposites shall not be welded to geomembranes.
- Geocomposites shall only be cut using approved cutting tool.
- The Subcontractor shall take necessary precautions to prevent damage to underlying layers, during placement of the geocomposite.
- During placement of geocomposites, care shall be taken not to entrap dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it shall be cleaned prior to placement of the next material on top of it.
- Vehicles shall not be permitted on the geocomposite unless approved by the Contractor.
- Tools shall not be left on or under the geocomposite.
- In geocomposites, tearing the geotextile away from the geonet shall not be allowed, except at seam locations in corners, as approved by the CQA Subcontractor.
- After deployment, geocomposite shall be covered to prevent exposure to UV radiation (sunlight), within a maximum period of 14 calendar days.

6.5.5 Joining

The geocomposite drainage layers shall be joined, as described below:

- Adjacent sections of geocomposite shall be overlapped, according to the manufacturer's directions.
- Overlaps shall be secured by tying. Acceptable tying devices include plastic fasteners or polymer braid. Tying devices shall be white or yellow for easy observation. Metallic joining devices are not allowed.
- Overlaps shall be secured every 1.5 meters (5 feet), along slopes and on the floor of the landfill. Along end-to-end seams, spot-weld and tie two rows 75 millimeter (3 inches) apart. Spot-weld and tie each row at 150-mm (6-inch) intervals; stagger weld or ties between rows.
- No horizontal seams shall be allowed on sideslopes provided rolls can be manufactured to sufficient length. If required because of manufacturing limitation end seams shall be staggered.
- If more than one layer of geocomposite is installed, joints shall be staggered.
- Top geotextile component of the geocomposite shall be sewn.

6.5.6 Repair

The geocomposite shall be repaired, as described below:

- Remove the damaged or un-bonded area of geocomposite.
- Cut a piece of geocomposite to fit over the repair area. Geocomposite shall fit over repair area and be tied similar to end-to-end seams.
- Remove any dirt or other foreign material that may have entered the geocomposite.
- Geocomposite damage greater than 4 sf shall require removal of a full roll width of damaged area.

6.5.7 Materials in Contact with Geocomposites

The Subcontractor shall place soil materials located on top of a geocomposite layer in such a manner as to ensure that the following conditions are satisfied:

- No damage to the geocomposite;
- No slippage of the geocomposite on underlying layers; and
- No excess tensile stresses in the geocomposite.

Placement of soil materials shall begin at the bottom of the sideslopes and progress upslope, or laterally, at about the same elevation in such a manner that a full layer of material is covering the geosynthetics downslope, from the area being covered.

6.6 Anchor Trench

6.6.1 Pre-Construction

There are no pre-construction requirements for the proposed anchor-trench backfill materials.

6.6.2 Construction

During placement of backfill in the anchor trenches, CQA personnel shall observe the placement operations on a periodic basis and perform the following:

- Visually observe the material for contamination with debris or deleterious material;
- Visually observe the material for particle size;
- Visually observe that the material is moisture conditioned and compacted, as specified;
- Observe the placement of the material to document minimum thickness under equipment, to prevent damage to the underlying materials; and
- Visually observe to detect any damage to the underlying liner materials.

Tests shall be conducted in accordance with the methods and procedures specified in the table provided in Section 4.2.2.

6.7 LCS System Equipment and Components

6.7.1 Electrical System and Pump Controls

The electrical system that controls the leachate pumps shall be checked for proper installation and operation. CQA personnel shall perform the following activities:

- Receipt inspections of electrical components (verify Underwriters Laboratories (UL), listings, etc.);
- Review the Construction Subcontractor's submittals and proposed equipment to document compliance with the specifications;
- Verify and document final tagging, labeling, and marking of the electrical systems (i.e. breaker, outlets, disconnects, switches, etc.); and

- Perform or review component checks of resistance, grounding, and load prior to complete system check.

6.7.2 Pumps, Piping, Meters, and Valves

The pumps, piping, instruments (such as the flow meters), and valves that are included in the leachate collection (removal and transfer) system shall be examined and tested at the system level for conformance to the specifications and proper performance. CQA personnel shall perform the following activities, in conjunction with these items:

- Review Construction Subcontractor's submittals and equipment deliveries to the site to verify conformance with the specifications;
- Review the results of Subcontractor's acceptance testing of the piping system;
- Review system performance checks to confirm operation, in accordance with the specifications; and
- Review the complete leachate removal system performance using the installed pumps, as described in the specifications.

6.8 Geotextile

Should a geocomposite not be used a geotextile will be installed over the drainage material and secured to prevent wind damage. The CQA Monitor will observe the placement of the geotextile and record the panel locations on the record drawings.

6.8.1 Manufacturing

The geotextiles shall be manufactured from polypropylene resin. The geotextiles will be supplied to the site in factory rolls. The minimum requirements for the geotextiles are presented in the table below.

Material Properties-Geotextiles

Property	Qualifier	Unit	Specified Value	Test Frequncy	Test Method
6 OZ/YD^2 GEOTEXTILE					
Mass/Unit Area	Nominal	oz/yd^2	6	1/100,000 ft^2 min. 1 per lot	ASTM D5261
Grab Strength	Minimum	lbs	150	1/100,000 ft^2 min. 1 per lot	ASTM D4632
UV Resistance	Minimum	%	≥70 % strength	1/100,000 ft^2 min. 1 per lot	ASTM D4355
8 OZ/YD^2 GEOTEXTILE					

Mass/Unit Area	Nominal	oz/yd^2	8	1/100,000 ft^2 min. 1 per lot	ASTM D5261
Grab Strength	Minimum	lbs	220	1/100,000 ft^2 min. 1 per lot	ASTM D4632
UV Resistance	Minimum	%	≥70 % strength	1/100,000 ft^2 min. 1 per lot	ASTM D4355

QC testing will be performed by the Geotextile Manufacturer to demonstrate compliance with the stated test methods. Prior to delivery of any geotextile rolls to the site, the Geotextile Manufacturer will provide the CQA Engineer with the following information:

- The resin supplier, supplier location, and brand name
- Test results conducted by the geotextile and/or resin manufacturer to document the quality of the resin used in geotextile fabrication
- The quality control plan that the Geotextile Manufacturer will be using for the geotextile being supplied.

Every roll delivered to the site must be manufactured and inspected by the Geotextile Manufacturer according to the following requirements:

- Quality resins must be used containing no more than two percent recycled material by weight as determined by thermo-gravimetric analysis. Recycled polymer will be limited to material generated within the Geotextile Manufacturer's plant and from the same grade and type of resin defined in this plan.
- The geotextile must be certified needle-free.
- The geotextile must be free of holes and any other signs of contamination by foreign matter.

The Geotextile Manufacturer will provide certification, based on tests performed by the Manufacturer's laboratory or other outside laboratory contracted by the Manufacturer, that the geotextile supplied under this plan meets the stated specifications.

6.8.2 Delivery, Handling, and Storage of Geotextile Rolls

Transportation of the geotextile rolls to the job site is the responsibility of the Geotextile Manufacturer. All on site handling is the responsibility of the Installer. The geotextile will be protected during shipment from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. Upon receipt of material shipments at the site, the Installer shall inspect all materials for defects in the manufacturing process and for

damage during transportation. Materials judged to be severely damaged shall be rejected and removed from the site. Minor damage and defects shall be repaired by the Installer. The geotextile rolls will be stored on site in a manner which prevents excessive UV exposure prior to installation.

The CQA Engineer will be responsible throughout the pre-construction and construction periods
for observing and documenting that the Installer uses adequate handling equipment for moving the geotextile rolls.

The CQA Engineer will be responsible for making certain that the manufacturer, geotextile type,
and thickness of each roll in a shipment is correct. The CQA Engineer will also maintain a log of
the geotextile rolls delivered throughout the construction process. This log shall include, at a minimum the following:

- Manufacture date
- Date of receipt at the site
- Roll and lot batch numbers.

6.8.3 Placement Criteria

The Installer will handle geotextiles in such a manner to verify that they are not damaged. The CQA Engineer will observe and document that all of the following steps are performed by the Installer:

- On side slopes, the geotextile shall be rolled down the slope in such a manner as to keep the geotextile continually in tension.

- In the presence of wind, all geotextiles will be secured by suitable methods that are protective of the geotextile and the underlying geomembrane.
- Geotextiles will be cut using only approved geotextile cutters. If the geotextile is in place at the time of cutting, special care shall be taken to prevent damage to the underlying geomembrane.
- The Installer must take necessary precautions to prevent damage to the geomembrane liner during placement of the geotextile.
- During placement of the geotextile over the geomembrane, care must be taken to prevent the entrapment of foreign matter or excessive moisture between the geotextile and geomembrane.
- A visual inspection of the geotextile must be carried out over the entire surface after installation by the Installer, to verify that no potentially

harmful foreign objects or excessive moisture are present. All such foreign objects or material shall be removed.

6.8.4 Seams and Overlaps

The following requirements must be used with regard to seaming and overlapping of geotextile rolls:

- Geotextile seams must be continuously welded or sewn and will be overlapped a minimum of 3 inches prior to seaming. Spot seaming will not be allowed.
- Horizontal seams on the landfill side slopes (except as part of a patch) will be allowed only at the approval of the CQA Engineer.
- The Installer must pay particular attention to seams to verify that no earthen materials are inadvertently trapped beneath the geotextile.
- Any sewing must be performed using polypropylene thread manufactured of the same base material as the geotextile. The thread shall be resistant to degradation by UV radiation.

The CQA Engineer will observe and document that the Installer follows all of the seaming and overlapping protocol. The CQA Engineer will perform a final geotextile examination after installation of the geotextile layer has been completed to detect the presence of holes or tears and to examine seams for tension due to excessive stretching of the fabric during installation. Repairs will be made for areas not conforming to acceptable practices.

6.8.5 Defects and Repairs

This section applies to all defects including damage during placement and repairs undertaken based on defects detected during examinations, tests, or visual observations performed on the geotextile material and on field seams.

The CQA Engineer will examine each roll for damage after placement, but prior to seaming, and will determine which rolls or portions of rolls should be rejected, repaired, or accepted. Damaged rolls or portions of rolls, which have been rejected, will be marked, and their removal from the site will be recorded by the CQA Engineer.

All seam and non-seam areas of the geotextiles must be visually observed and documented by the CQA Engineer for identification of defects, holes, undispersed raw materials, large wrinkles, and any signs of contamination by foreign matter. The surface of the geotextiles will be clean at the time of visual observation.

Each location that fails visual observation will be marked by the CQA Engineer and repaired by the Installer. Work will not proceed in an area where defects are identified

until suitable repairs are made. Each repair will be visually observed, numbered, and logged by the CQA Engineer.
Any holes or tears in the geotextile must be reported to the CQA Engineer and repaired as follows:

- A patch made from the same geotextile will be sewed, welded, or heat-bonded in place, with a 3-inch minimum overlap in all directions
- Care must be taken to remove any soil, excessive moisture, or other material that might have penetrated a torn geotextile.

6.8.6 Placement of Soil Materials

Placement of soil materials on top of the geotextile must be performed by the Contractor in such a manner as to confirm the following:

- Damage of the underlying geotextile or geomembrane does not occur
- Slippage of the geotextile on the underlying geomembrane is minimal
- No excess tensile stresses are imposed on the geotextile or geomembrane.

6.9 Protective Layer

The protective layer over a geocomposite LCS will consist of 12 inches of soil and 60 inches of select trash. The protective layer over a sand/gravel LCS will consist of 60 inches of select waste. Once the protective layer is placed, wheeled vehicles can drive over the newly constructed area. The CQA Engineer will not oversee placement of select waste or protective soil above the LCS.

6.10 Survey Requirements

The survey requirements for the drainage layer are 0.0 feet to +0.2 feet and can be directly measured. The survey requirements for the protective layer are 0.0 feet to +0.2 feet and can de directly measured. The drainage layer and protective cover will be surveyed on a grid spacing of 50-feet or less and at the tops and toes of slopes at a spacing of 50-feet or less.

7 FINAL COVER CONSTRUCTION

7.1 General

The CQA Monitor shall observe that the final cover is placed at a maximum overall slope of 4 horizontal to 1 vertical (4H:1V) with the exception of the north face of the landfill that will be placed at a maximum overall slope of 3H:1V and a minimum slope of 20H:1V.

7.2 Water Balance Final Cover

The water balance cover consists of 12 inches of intermediate cover and 30 inches of water storage layer.

7.2.1 Intermediate Cover

Intermediate cover is placed during landfilling. The thickness is verified prior to placing the water storage layer.

Required Intermediate Cover Layer Verification

Properties (Test Method)	Frequency	Required Result
Thickness (survey)	50 foot grid	1.0 ft to +1.5 ft

Note: ft = feet

7.2.2 Water Storage Layer

The water storage layer will be loosely placed in a single 30-inch lift. Moisture and density measurements will be taken to measure the placed material compaction. The water storage layer is placed as a 30-inch veneer over the intermediate cover soil layer and does not have specific design elevations. The water balance cover will be constructed in accordance with the guidelines set forth in the Final Guidance Document for Water Balance Covers in Colorado from the CDPHE, dated March of 2013.

Required Water Storage Layer Verification Laboratory Testing

Properties (Test Method)	Frequency	Required Result
Texture (ASTM D7928)	1 per 1,500 CY	Inside acceptable zone 1
Standard Proctor (ASTM D698)	1 per 3,000 CY*	NA
Water Content (ASTM D2216)	As Appropriate	NA
pH (EPA Method SW-846 SW 9045C)	1 per 6,540 cy*	6.0-8.4
$CaCO_3$ (USDA Handbook No. 60)	1 per 6,540 cy*	<15% by weight

Notes: cy = cubic yards
+refers to a soil composition on the USDA Textural Triangle for Ecozone 1 in the Guidance Document for Water Balance Covers in Colorado
*Or less frequently based on change in soil type as determined by the CQA Engineer

Required Water Storage Layer Verification Field Testing

Properties (Test Method)	Frequency	Required Result
Thickness (Survey)	3 per acre per lift	2.5 ft
In-Situ Density and Moisture Content (ASTM D6938)	3 per acre per lift	80%-90%
Moisture Content (ASTMD 2216)	3 per acre per lift	Less than Optimum Moisture Content

Notes: ft = feet cy = cubic yards

The water storage layer consists of a 30-inch thick lift of clayey soil placed in a single "monolithic" lift to minimize over-compaction. These layers shall not be compacted and shall be placed and shaped with low ground pressure (LGP) equipment such as an LGP dozer.

The upper 6 inches will be considered vegetative growth layer. The upper 6 inches of soil are to be tested for nutrient content, and results of these tests will be provided to the CQA Engineer. Soil amendments such as finished compost may be used as needed to support revegetation efforts. Some additional material may be imported if it is determined that onsite materials are insufficient. Any field tests, soil sample locations, and survey measurements will be recorded in reports by the CQA Engineer or his representative including locations (by site grid station) and elevations of all field tests and laboratory sample points.

7.2.3 Placement Criteria

Prior to placement of the water balance cover soils the subgrade shall be prepared as follows:

- the subgrade shall be proof rolled to identify soft areas in the intermediate cover and repairs shall be made as needed to achieve a stable surface.
- Grade the subgrade to achieve a surface consistent with the approved design contours in preparation for water balance cover construction. Relatively steeper side slopes (> 5 percent) should be roughened using appropriate equipment prior to placement of cover soil.

The water balance cover soils shall be placed with emphasis on the following:

- Removal of debris and any deleterious materials that would negatively affect the design intent of the water balance cover, as determined by the CQA Engineer
- Removal of frozen soils
- Clod size less than 4 inches in the longest dimension, with clod defined as a soil aggregation that does not break down by hand
- Nominal compaction of the water balance cover soils.

As discussed above, the soils shall not be compacted and shall be placed and shaped with LGP equipment. The LGP equipment shall "track-walk" the soil after placement to aid in the removal of any voids created during placement. Track-walking will be performed by moving the LGP equipment back and forth one time in one direction (i.e., north-south), and then by crossing the same area one time in a perpendicular direction (i.e., east-west).

Moisture content shall be less than the optimum at the time of placement. The Soils Testing Laboratory, CQA Engineer, or both, shall document that backfilling and recompacting operations are conducted in accordance with the Design Plans and Drawings, and with this CQA Plan. If over-compaction occurs, the soil may be ripped or disked and then re-compacted to attain the required 80 to 90 percent compaction specification. This procedure is intended only for alleviation of over-compaction and will not be used as the standard technique for water balance cover soils placement.

8 DOCUMENTATION

8.1 Daily Reports

Each of the CQA Monitors shall complete daily reports when they are onsite. Entries may include, but not be limited to, the following information:

- Reports on any meetings held and the results of those meetings;
- Equipment and personnel being used in each location, including subcontractors;
- Descriptions of areas being observed, inspected, samples collected, and testing results;
- Description of materials delivered to the site, including any quality verification (manufacturer's certification) documentation;
- Decisions made regarding use of material and/or corrective actions to be taken in instances of substandard quality;
- Unique identifying sheet numbers of inspection data sheets, problem reporting, and corrective measures reports used to substantiate the decisions described in the preceding item; and
- Any deviations from the construction documents.

The CQA Engineer shall review each daily report.

8.2 Design Changes and Clarifications

Requests for modifications to the CQA Plan, or design changes, shall be made by memorandum to the owner; with copies to the CQA Engineer, and will require approval from CDPHE.

8.3 Final Documentation

At the completion of the project, a CQA report that incorporates the field-testing, manufacturer testing, and lab testing along with as-built drawings, shall be prepared by the CQA Engineer and submitted to the owner and CDPHE. The as-built drawings shall include scale drawings depicting depths, plan dimensions, elevations, and fill thicknesses; and will be sealed by a Colorado Professional Engineer and retained by the owner. The CQA Report shall include documentation of each construction component, monitored by the CQA Monitor, and shall certify that the facility was constructed in accordance with the EDOP, the CQA Plan, and construction documents. The report will also include correspondence with the Division regarding the project, record survey drawings, daily

reports prepared for the project, a photographic log for the project, and geosynthetics deployment logs. The report shall be sealed by a Professional Engineer registered in the State of Colorado and will certify that each construction component was constructed in accordance with the EDOP, CQA Plan, and construction documents. Use of any newly constructed portion of the landfill shall commence after CDPHE approves the CQA report.

8.4 Storage of Records

During the construction of MCLF, the CQA Engineer shall be responsible for CQA documents. This includes the CQA Engineer's copy of the design criteria, construction documents, the CQA Plan, and the originals of the data sheets and reports.

The CQA Monitor shall maintain MQC documentation from the manufacturer including the following:

- The origin (resin supplier's name, resin production plant), identification (brand name, number), and production date of the resin;
- A list of quantities and descriptions of materials, other than the base polymer, that comprise the geomembrane;
- A copy of the quality control certificates issued by the resin supplier;
- Reports on the tests conducted by the manufacturer and the CQA Engineer to confirm that the quality of the resin used to manufacture the geomembrane satisfies the specifications;
- A statement that no recycled polymer is added to the resin or that recycled polymer is clean, does not exceed 2% by weight, and does not include material that has seen previous service life;
- A properties sheet including properties listed in the specifications, measured using test methods indicated in the specifications, or equivalent;
- Reports on the tests, including sampling procedures, conducted by the manufacturer and/or the CQA Engineer to confirm that the geomembrane meets the project specifications; and
- A certification that property values, given in the properties sheet, are guaranteed by the geomembrane manufacturer.

9 REFERENCES

Colorado Department of Public Health and Environment. (2010). *Solid Waste Guidance Document, Concerning Solid waste Site, and facility engineering Design Quality Assurance/Quality Control Plans for Disposal Cell Subgrade, Liner, Leachate Collection System (including Sumps) and Protective Layer Components*. Colorado: Colorado Department of Public Health and Environment.

Colorado Department of Public Health and Environment. (2013). *Guidelines for Design, Construction, and Development of Water Balance Covers According to the Regulations Pertaing to Solid Waste Sites and Facilities 6CCR 1007-2, Part 1*. Colorado: Colorado Department of Public Health and Environment.