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SOLID WASTE GUIDANCE DOCUMENT

Title: **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**

Date: January 14, 2010

Purpose: To improve the efficiency of the regulatory review process by clarifying the desired content of solid waste site and facility engineering design Quality Assurance/Quality Control (QA/QC) Plans for disposal cell subgrade, liner, leachate collection system (including sumps) and protective layer components that are required to be submitted to the Colorado Department of Public Health and Environment (Department) Hazardous Material and Waste Management Division (Division) for review and approval. In addition, various associated design concepts that were related by the Division to stakeholders at meetings convened during the guidance development process are put forth in italics below.

Disclaimer: The design content presented in this guidance document is not intended to supersede previously approved design documents. The design content set out in this document is intended solely as guidance. Such guidance is not intended and cannot be relied upon to create rights, substantive or procedural, enforceable by any person or party in litigation with the Department. The Department reserves the right to be at variance with this guidance. The Department also reserves the right to change this guidance at any time with appropriate publication.

Proposed Distribution: Any interested party, by request, and to the Division Homepage.

Statement of Guidance: The Division's Solid Waste and Material Management Unit have recognized a need to establish an improved level of consistency in the area of quality assurance and quality control plans. This guidance is an effort to promote consistency regarding the desired content of such plans to facilitate the Division's review and approval process. This guidance narrative generally corresponds with the construction sequence of the landfill elements identified in the following table proceeding from bottom to top.

Background and Discussion: Consistent with the Division's Solid Waste Guidance Document Concerning Solid Waste Site and Facility Engineering Design/As-built Documents (dated April 16, 2008), written QA/QC plans must be developed and implemented for all engineered waste containment facility structures with the exception of ancillary components (e.g., entrance roads, gate houses, maintenance buildings, etc.). Where applicable, an effort has been made to incorporate the QA/QC tests and test frequencies found in the EPA Technical Guidance Document entitled Quality Assurance and Quality Control for Waste Containment Facilities as well as Waste Containment Facilities 2nd Edition (WCF) into this guidance document (see references). Updated test methods are put forth in some cases.

Guidance: QA/QC is divided into manufacturing quality assurance (MQA)/manufacturing quality control (MQC) and construction quality assurance (CQA)/construction quality control (CQC). Ideally, QA (i.e., measures taken by the QA organization) should be independent of QC (i.e., measures taken by the manufacturer, installer or contractor).

It is expected that an increased level of QA/QC may be incorporated into designs involving materials that exhibit a relatively higher degree of inherent variability or uncertainty. Deviations from conventional QA/QC test frequencies and ASTM methods contained in this guidance may be justified based on supporting documentation. In any case, suitable standard equipment that enhances effective execution of a given QA/QC task and that is capable of meeting specified accuracies and tolerances should be employed.

Waste containment facility disposal cell engineering design should include, but not be limited to, QA/QC plans that include measurable requirements for the cell subgrade, liner, leachate collection system (including sumps) and protective layer components. Cell structures may consist of natural or manmade materials. *In general, geosynthetic clay liners (GCLs) should only be used as a component of a composite liner (e.g., in conjunction with natural low permeability soils or geomembranes).*

Survey Requirements - Survey methodology and/or other pertinent measurement procedures should be incorporated in the QA/QC plan to verify the applicable criteria and specifications put forth in the design documentation. Horizontal and vertical survey accuracies (i.e., as opposed to construction tolerances) should be a maximum 0.1-foot and a maximum 0.01-foot, respectively, and such maximum survey accuracies should be inherent in a survey performed by a Colorado licensed Professional Land Surveyor. Less stringent survey accuracies may be specified to identify test/sample locations.

The Division prefers that the subgrade surface, top of soil liner, top of soil drainage layer and top of protective layer (as applicable) vertical elevations be surveyed at coincident horizontal coordinate points (i.e., at "stacked" points located vertically above the corresponding subgrade horizontal survey coordinate point locations) to facilitate layer thickness determinations at a maximum 50-foot grid spacing and at maximum 50-foot intervals along grade break lines (e.g., at top and toe of side slopes) and along leachate collector drain lines. If survey measurement locations are not stacked, the facility should interpolate from other suitable survey measurement locations (e.g., using Trigonometric

methods, software programs, etc.) survey measurements to project the data to locations stacked above subgrade surface survey locations for the determination of feature thickness, slope and elevation. Alternatively, soil drainage layer material thickness may be measured using appropriate means other than vertical survey methods (e.g., physical measurements, etc.).

Survey of sumps should be performed at locations and at distance intervals sufficient to give a clear presentation of the three-dimensional configuration of sump components and their corresponding thicknesses. Similarly, survey of pipe segments (e.g., at points located along top of pipe) should be performed at maximum 50-foot intervals, at changes in pipe direction and at the ends.

Subgrade - QA/QC design requirements for subgrade should focus on achieving a stable surface suitable for liner construction/installation. The subgrade should be free of deleterious material and be reworked as necessary to overcome the effects of adverse weather or other undesirable conditions. The subgrade may have acceptability criteria relative to the surface underlying the liner such as particle size limitations and or relative roughness requirements, etc., depending on the liner design components. QA/QC design requirements for structural fill should ensure suitability and proper placement/compaction of the backfill material.

Soil Liners - Similarly, QA/QC design requirements for compacted low permeability soil liners should ensure suitability of liner material, proper placement/compaction and subsequent protection (e.g., from freezing and desiccation). Soil liners should have limitations on particle/clod size. To facilitate positive drainage towards the sump, the soil liner surface should be smooth and free of undulations. Additionally, an evenly graded soil liner surface enhances attainment of intimate contact with an overlying geomembrane so as to form a composite liner.

Soil Liner Index Tests/Field Identification Methods/One Point Proctors - Application of professional judgment, laboratory index tests (e.g., gradations and Atterburg Limits), Field Identification of Soils (ASTM D2488 – Visual Manual Procedure) and one point proctors are methods that can be used to aid in determination of changes in soil types to facilitate usage of an appropriate proctor compaction curve for field moisture/density testing of the compacted low permeability soil liner. In general, a minimum of one one (1) point proctor should be performed per each day of cohesive soil liner placement. Field identification methods include, but are not limited to, the following properties/techniques: Color, Grain size, Moisture, Density, Dry Strength (measure of clay content by allowing a small specimen to dry and compressing with fingers), and Toughness Test (measure of clay content by ease of rolling and re-rolling a small specimen into approximately 3 mm diameter threads).

An Acceptable Zone (AZ) procedure based on using a "line of optimums" is the preferred method for developing moisture/density specifications for construction of a compacted low permeability soil barrier, which exclusively requires a hydraulic conductivity of 1 x 10^{-7} cm/s or less, compared with using "percent compaction" in conjunction with a range of moisture content requirements. The line of optimums is defined as the locus of optimum moisture content/maximum dry density points for compaction curves developed

on the same soils subjected to different specified compaction energies. The line of optimums is essentially parallel to the zero air voids curve (100% saturation), and typically corresponds to a soil saturation of about 85%. An adequate QA/QC requirement to ensure that a compacted low permeability soil liner will achieve a hydraulic conductivity of less than or equal to 1.0 x 10^{-7} cm/sec should state that at least 80% of field measured moisture content/dry density points fall on or above the line of optimums. See Reference number 4 below for supplemental information.

Soil Drainage Layer - QA/QC design requirements for soil drainage materials used in the cell leachate collection system (LCS) should ensure suitability of drainage material, proper placement and compaction (as applicable) and subsequent protection. Consistent with WCF recommendations, the CQA testing program should emphasize grain-size distribution analyses rather than hydraulic conductivity testing, with particular attention paid to the amount of fines present in the drainage material.

Accordingly, a demonstration should be made in terms of grain size distribution analyses, that the range of the soil drainage material source can achieve the minimum required permeability. The design requirements should be written in terms of the grain-size distribution analyses that correlate with attainment of the minimum required permeability, as based on the results of a successful demonstration.

The Soil Drainage Layers CQA grain size and hydraulic conductivity test frequencies in the following QA/QC TESTING TABLE are based on incorporation of a grain-size distribution specification(s) that correlates with attainment of the minimum required permeability. The Division strongly recommends that the hydraulic conductivity testing frequency should be increased to compensate for elimination of the grain-size distribution specification(s).

Synthetic LCS Materials - Suitable synthetic drainage materials may be proposed. *However, select trash should not be used for LCS drainage material.*

In order to minimize bio fouling, geotextile is not recommended as a filter wrap around collector piping or around gravel bedding used as a collector. However, it is believed that the greater surface area available from a geotextile blanket that overlies a drainage layer allows leachate flow prior to entering the collector pipe. The fabric may clog directly over the collector but continue to permit flow within a few feet of the collector and between collectors.[3]

Protective Layer – The integrity of LCS's should not be compromised by the intrusion of fine grained soils, overlying wastes or other contaminants or by penetration of heavy objects. Engineered protective layers (including appropriate soil filters and geotextiles) and supervised placement of innocuous "select trash" over leachate collection systems are examples where QA/QC measures may be employed to reduce potential adverse effects on the LCS's ability to transmit flow. Another advantage of employing engineered soil protective layers is to aid in mitigating potential adverse effects of desiccation and freeze/thaw cycles on an underlying soil liner's hydraulic conductivity. Additionally, engineered soil protective layers and geotextiles may be used to aid in mitigating potential degradation of geomembranes from ultra violet light.

QA/QC Reporting Requirements - A QA/QC Plan should include a description of the content of the associated QA/QC report (i.e., as-built certification report). A typical Table of Contents may be employed to facilitate this purpose. Emphasis should be placed on incorporating a QA/QC plan requirement that the QA/QC report identify deviations from the approved design. Preference is for the QA/QC data to be reported in a manner that minimizes the degree of technical effort required for review. Preference is for the QA/QC data to be stored and managed in an electronic system to facilitate future representations of the information. For instance, the QA/QC report should include an electronic copy of the survey data that is formatted in a readily discernable manner. As applicable, the QA/QC report should follow the same survey convention established for the design. Three-dimensional as-built topographic features should be verified to comply with corresponding engineering design contours, grades and elevations.

REFERENCES:

1) Technical Guidance Document – Quality Assurance and Quality Control for Waste Containment Facilities, USEPA, Office of Research and Development, Washington DC 20460, EPA/600/R-93/182, September 1993
2) Waste Containment Facilities, 2nd Edition, ASCE Press, David E. Daniel, Ph.D., P.E., Robert M. Koerner, Ph.D., P.E., Copyright © 2007
3) J.W. Spear, Sr., P.E., J Spear Associates
4) Field Performance of Compacted Clay Liners by Craig H. Benson, David E. Daniel, and Gordon P. Boutwell, Journal of Geotechnical and Geoenvironmental Engineering, May 1999

QA/QC TESTING TABLE

Tasks	TEST METHOD	TEST FREQUENCY	Appropriate Party
Protective Layer CQA		**Continuous observation of selective trash placement over unprotected LCS.**	**Verified by the Owner/Operator representative**
Leachate Collection Systems			
Geosynthetic Drainage Systems MQA			
Plastic Geopipe MQA			
HDPE Resin	ASTM D1248	Per MQA document	
Resin Melt Flow Index	ASTM D1238	Per MQA document	
Physical Dimensions	ASTM D2122	Min 1 test per 1000 ln ft	
Resin Density	ASTM D1505/792	"	
Plate Bearing Test	ASTM D2412	"	
Impact Resistance	ASTM D2444	"	
Geocomposites MQA:			
Geonet/Geotextile Resin			
Resin Density	ASTM D1505/D792	Minimum 1 test per lot[(4)]	
Resin Melt Flow Index	ASTM D1238	"	
Geonet Portion			
Density	ASTM D1505/D792	1 test per 100,000 ft^2 and minimum 1 test per lot[(4)]	
Thickness	ASTM D 5199	"	
Carbon Black	ASTM D4218	"	
Compression Strength	ASTM D1621	"	
Transmissivity	ASTM D4716	"	
Geotextile Portion			
Mass Per Unit Area	ASTM D5261	1 test per 100,000 ft^2 and minimum 1 test per lot[(4)]	

Tasks	TEST METHOD	TEST FREQUENCY	Appropriate Party
Grab Tensile Strength and Elongation	ASTM D4632	”	
Trapezoidal Tear Strength	ASTM D 4533	“	
Puncture Strength	ASTM D4833	“	
Permittivity	ASTM D4491	“	
Apparent Opening Size	ASTM D4751	“	
UV Stability	ASTM D4355	“	
Geocomposite			
Transmissivity	ASTM D4716	1 test per 100,000 ft^2 and minimum 1 test per lot[(4)]	
Ply Adhesion	ASTM D6636	“	
Soil Drainage Layers CQA			
Soil Drainage Layer Potential Borrow Source			
Grain Size	ASTM D422	1 per 2620 yd^3	
Hydraulic Conductivity	ASTM D2434	1 per 2620 yd^3	
Carbonate Content[(2)]	ASTM D4373 (soils)	1 per 2620 yd^3	
Carbonate Content[(2)]	ASTM D3042 (aggregates)	1 per 2620 yd^3	
Soil Drainage Layer After Placement			
Grain Size	ASTM D422	1 each hectare (4000 yd^2 area)	
Hydraulic Conductivity	ASTM D2434	1 each 3 hectares (12000 yd^2 area)	
Carbonate Content[(2)]	ASTM D4373 (soils)	1 per 2620 yd^3	
Carbonate Content[(2)]	ASTM D3042 (aggregates)	1 per 2620 yd^3	
Low Permeability Liner Construction			

Tasks	TEST METHOD	TEST FREQUENCY	Appropriate Party
Synthetic Liner Material			
Geomembrane (HDPE) MQA			
Manufacturer MQA Information			
Thickness Smooth/Textured	ASTM D5199/D5994	Per roll	
Asperity Height	GRI GM 12	Every 2nd roll	
Density	D792 or D1505	Every 200,000 lb	
Ultimate Tensile Strength	ASTM D638/6693	Every 20,000 lb	
Yield Stress	"	"	
Break Stress	"	"	
Yield Elongation	"	"	
Break Elongation	"	"	
Tear Resistance	ASTM D1004	Every 45,000 lb	
Puncture Resistance	ASTM D4833	Every 45,000 lb	
Stress Crack Resistance	ASTM D5397	1 per 2 resin lots	
Carbon Black Content	ASTM D1603	Every 20,000 lb	
Carbon Black Dispersion	ASTM D5596	Every 45,000 lb	
Standard Oxidative Induction Time	ASTM D3895	Every 200,000 lb	
High Pressure Oxidative Induction Time	ASTM D5885	Every 200,000 lb	
Oven Aging	ASTM D5721	Per each formulation	
UV Resistance	GRI GM 11	Per each formulation	
Geomembrane (HDPE) Conformance Testing MQA			
Thickness	ASTM D5994	1 test per 100,000 ft^2 and minimum 1 test per lot[(4)]	
Asperity	ASTM D 7466	"	
Density	ASTM D 1505/D 792	"	
Carbon Black Content	ASTM D 1603	"	
Carbon Black Dispersion	ASTM D 5596	"	
Tensile Strength/Elongation	ASTM D638/6693	"	
Puncture	ASTM D4833	"	
Tear	ASTM D1004	"	
Resin (HDPE) MQA			
Density	ASTM D1505 or ASTM D792 Method B	1 test per resin batch[(5)]	

Tasks	TEST METHOD	TEST FREQUENCY	Appropriate Party
Melt Index	ASTM D1238 Condition E	1 test per resin batch[5]	
OIT	ASTM D3895 (1 atm at 200° C)	1 test per resin batch[5]	
Extrudate Rod or Bead MQA			
Density	ASTM D 1505 or ASTM D 792 Method B	1 test per resin lot[4] or batch[5] of extrudate or bead used for extrusion welding	
Carbon Black Content	ASTM D 1603	"	
Melt Index	ASTM D 1238 Condition E	"	
Geomembrane (HDPE) Construction CQA			
Placement/Panel Layout			
Subgrade Prep			
Destructive Seam Testing			
Shear Strength/Shear Elongation at Break	ASTM D 6392	1 per 750 lineal feet of seam	
Peel Adhesion	"	"	
Peel Separation	"	"	
Anchor Trenches			
Trial Seams	ASTM D 6392	At the beginning of each shift and when the ambient temperature ≥ 104° F measured 6-inches above the geomembrane surface per machine and per operator and with each change in temp > 20° F, and every 5 hours.	
Nondestructive Seam Testing			
Vacuum Box	ASTM D 5641	Continuous over full length	
Air Pressure	ASTM D 5820	Continuous over full length	
Electric Leak Detection			
Defects and Repairs			

Tasks	TEST METHOD	TEST FREQUENCY	Appropriate Party
Geosynthetic Clay Liner (GCL)			
Bentonite MQA			
Swell Index	ASTM D5890	1 test per 100,000 ft^2	
Fluid Loss	ASTM D5891	1 test per 100,000 ft^2	
Composite MQA			
Peel Strength	ASTM D6496	1 test per 100,000 ft^2	
Grab Strength/Elongation	ASTM D4632	1 test per 100,000 ft^2	
Bentonite Mass/Unit Area MARV[(3)]	ASTM D5993	1 test per 100,000 ft^2	
Permeability/Flux, max	ASTM D5887	1 test per 100,000 ft^2	
GCL Conformance Testing CQA			
Placement/Panel Layout			
Subgrade Prep			
Moisture Content	ASTM D 2216	1 test per 100,000 ft^2	
Bentonite Mass Per Unit Area	ASTM D 5993	1 test per 100,000 ft^2	
Index Flux	ASTM D 5887	1 test per 100,000 ft^2	
Low Permeability Soils Liner Lift			
Construction Testing CQA			
Water Content	ASTM D6938 Nuke Gauge	4 per acre/lift: 0.25 ac	
	ASTM D2216 Lab Test	1 per 2.5 acres	
Density	ASTM D6938 Nuke Gauge	4 per acre /lift: 0.25 ac	
	Lab Test – See Note 1	1 per 2.5 acres	
Gradation Testing	ASTM D422	1/1,000 yd^3	
Atterberg Limits	ASTM D4318	1 per 1,000 yd^3 or 1 per lift whichever yields larger number of tests	
Line of Optimums Evaluation using 3 Proctor technique		1 per 10,000 yd^3 or change of material type	
Specific Gravity	ASTM D854	1 per material type	

Tasks	TEST METHOD	TEST FREQUENCY	Appropriate Party
Modified Line of Optimums Evaluation using 1 Proctor technique		1 per 5,000 yd^3 or change of material type	
Degree of Saturation Calculation		1 per 5,000 yd^3 or change of material type	
Hydraulic Conductivity with Line of Optimums(1)		1/20,000 yd^3	
Hydraulic Conductivity without Line of Optimums(1)		1/10,000 yd^3 or one per lift whichever yields the larger number of tests	
Max loose lift thickness	Such that compacted lift thickness is no greater than length of penetrating feet, tolerance: + 0.0”	Frequency defined per professional judgment	
Borrow Source Testing Before Construction CQA			
Water Content	ASTM D2216	1 test per 2620 yd^3	
Atterberg Limits	ASTM D4318	1 test per 6540 yd^3	
Percentage Fines	ASTM D422/1140	1 test per 6540 yd^3	
Percent Gravel	ASTM D422	1 test per 6540 yd^3	
Compaction Curve	ASTM D698	1 test per 6540 yd^3	
Hydraulic conductivity	ASTM D5084	1 test per 13080 yd^3	
Sub-grade Preparation			
Scarification	Should be scarified prior to placement of initial lift of soil liner material.		
Elevation and slope verification	Standard approved survey practices.		
Proof rolling	No more than 2” deflection allowable based on visual observations, or less as needed to meet specified liner compaction density.	Continuous observations documented in a daily log while activity ongoing	Experienced engineering technician, construction materials testing technician, or geologist.
Initial cut and fill to achieve rough base grades			
Grubbing: tree, rock, debris removal	Should include material disposal. Note: unacceptable material in the sub-grade should be detailed in the spec.		

Tasks	TEST METHOD	TEST FREQUENCY	Appropriate Party
Survey			
Individual unit survey	Standard approved survey practices.		PLS, or under the direct supervision of the PLS
Initial boundary survey (existing conditions)	Standard approved survey practices. Should establish site-wide and unit specific grid system.		PLS, or under the direct supervision of the PLS

1) ASTM D-1587 is the method for obtaining an undisturbed sample of a fine grained cohesive soil. The section of undisturbed sample can be cut or trimmed from the sampling tube to determine bulk density or hydraulic conductivity. This method should not be used for soils containing any particles > 1/6-th the diameter of the sample.
2) Soil Drainage Material: The frequency of carbonate content testing should be reduced to 1 per 20,000 m^3, or entirely eliminated, for those drainage materials that obviously do not and cannot contain significant carbonates (e.g., crushed basalt). Some commercial laboratories have developed alternative calcium carbonate testing methods.
3) MARV – Minimum Average Roll Value
4) Resin lot as defined by the pertinent manufacturer.
5) Resin batch as defined by the pertinent manufacturer.

	CQA TEST FREQUENCY EVALUATION				
Media Test Type	Test Method	Test Frequency (vol, weight &/or x,y, z)	# Tests Required	# Test Performed	# Tests Passed
Protective Layer CQA					
Soil Drainage Layers CQA					
Potential Borrow Source					
Grain Size	ASTM D422	1 per 2000 m^3/2620 yd^3			
Hydraulic Conductivity	ASTM D2434	1 per 2000 m^3/2620 yd^3			
Carbonate Content	ASTM D4373	1 per 2000 m^3/2620 yd^3			
On site after placement					
Grain Size	ASTM D422	1 each hectare (4000 yd^2 area)			
Hydraulic Conductivity	ASTM D2434	1 each 3 hectares (12000 yd^2 area)			
Carbonate Content	ASTM D4373	1 per 2000 m^3/2620 yd^3			
Low Permeability Liner Construction CQA					
Synthetic Liner Material					
Geomembrane (HDPE) Construction CQA					
Placement/Panel Layout					
Subgrade Prep					
Destructive Seam Testing					
Shear Strength/Shear Elongation at Break	ASTM D 6392	1 per 750 lineal feet of seam			
Peel Adhesion	"	"			
Peel Separation	"	"			
Anchor Trenches					

	CQA TEST FREQUENCY EVALUATION				
Media Test Type	Test Method	Test Frequency (vol, weight &/or x,y, z)	# Tests Required	# Test Performed	# Tests Passed
Trial Seams	ASTM D 6392	At the beginning of each shift and when the ambient temperature ≥ 104° F measured 6-inches above the geomembrane surface per machine and per operator and with each change in temp > 20° F, and every 5 hours.			
Nondestructive Seam Testing					
Vacuum Box	ASTM D 5641	Continuous over full length			
Air Pressure	ASTM D 5820	Continuous over full length			
Electric Leak Detection					
Defects and Repairs					
Geosynthetic Clay Liner (GCL)					
Placement/Panel Layout					
Subgrade Prep					
GCL Conformance Testing CQA					
Moisture Content	ASTM D 2216	1 test per 100,000 ft^2			
Bentonite Mass Per Unit Area	ASTM D 5993	1 test per 100,000 ft^2			
Index Flux	ASTM D 5887	1 test per 100,000 ft^2			
Low Permeability Soils Liner					
Construction Testing CQA					
Water Content	ASTM D6938 Nuke Gauge	4 per acre/lift: 0.25 ac			
	ASTM D2216 Lab Test	1 per 2.5 acres			
Density	ASTM D6938 Nuke Gauge	4 per acre /lift: 0.25 ac			
	Lab Test – See Note 1	1 per 2.5 acres			
Gradation Testing	ASTM D422	1/1,000 yd^3			

	CQA TEST FREQUENCY EVALUATION				
Media Test Type	Test Method	Test Frequency (vol, weight &/or x,y, z)	# Tests Required	# Test Performed	# Tests Passed
Atterberg Limits	ASTM D4318	1 per 1,000 yd^3 or 1 per lift whichever yields larger number of tests			
Line of Optimums Evaluation using 3 Proctor technique		1 per 10,000 yd^3 or change of material type			
Specific Gravity	ASTM D854	1 per material type			
Modified Line of Optimums Evaluation using 1 Proctor technique		1 per 5,000 yd^3 or change of material type			
Degree of Saturation Calculation		1 per 5,000 yd^3 or change of material type			
Hydraulic Conductivity with Line of Optimums		1/20,000 yd^3			
Hydraulic Conductivity without Line of Optimums		1/10,000 yd^3 or one per lift whichever yields the larger number of tests			
Max loose lift thickness	Such that compacted lift thickness is no greater than length of penetrating feet, tolerance: + 0.0”	Frequency defined per professional judgment			
Borrow Source Testing CQA					
Water Content	ASTM D2216	1 test per 2620 yd^3			
Atterberg Limits	ASTM D4318	1 test per 6540 yd^3			
Percentage Fines	ASTM D422/1140	1 test per 6540 yd^3			
Percent Gravel	ASTM D422	1 test per 6540 yd^3			
Compaction Curve	ASTM D698	1 test per 6540 yd^3			
Hydraulic conductivity	ASTM D5084	1 test per 13080 yd^3			
Subgrade Preparation					
Scarification	Should be scarified prior to placement of initial lift of soil liner material.				
Elevation and slope verification	Standard approved survey practices.				
Proof rolling	No more than 2” deflection allowable based on visual observations, or less				

	CQA TEST FREQUENCY EVALUATION				
Media Test Type	Test Method	Test Frequency (vol, weight &/or x,y, z)	# Tests Required	# Test Performed	# Tests Passed
	as needed to meet specified liner compaction density.				
Initial cut and fill to achieve rough base grades					
Grubbing: tree, rock, debris removal	Should include material disposal. Note: unacceptable material in the sub-grade should be detailed in the spec.				
Survey					
Individual unit survey	Standard approved survey practices.				
Initial boundary survey (existing conditions)	Standard approved survey practices, should establish site-wide and unit specific grid system.				

	CQA TEST RESULT EVALUATION								
Media Test Type	Test Method	Spec Rqrmnt	Test Failed Identifier	Failed Test Loc (x,y)	Failed Value	Re-test #	Re-test Loc (x,y)	Re-test Value	Comments
LINER SOIL **Hydraulic Conductivity** **EXAMPLE**	ASTM D5084	$\leq 10^{-7}$ cm/sec	9		10^{-4}				Failed
			9R			9.1		10^{-5}	Failed
			9RR			9.2		10^{-8}	Passed
ABC									
CDE									
EFG									
GHI									
Protective Layer CQA									
Soil Drainage Layers CQA									
Potential Borrow Source									
Grain Size									
Hydraulic Conductivity									
Carbonate Content									
On site after placement									
Grain Size									
Hydraulic Conductivity									
Carbonate Content									

	CQA TEST RESULT EVALUATION								
Media Test Type	Test Method	Spec Rqrmnt	Test Failed Identifier	Failed Test Loc (x,y)	Failed Value	Re-test #	Re-test Loc (x,y)	Re-test Value	Comments
Low Permeability Liner Construction CQA									
Synthetic Liner Material									
Geomembrane (HDPE) Construction CQA									
Placement/Panel Layout									
Subgrade Prep									
Destructive Seam Testing									
Shear Strength/Shear Elongation at Break	ASTM D 6392								
Peel Adhesion	"								
Peel Separation	"								
Anchor Trenches									
Trial Seams	ASTM D 6392								
Nondestructive Testing									
Vacuum Box	ASTM D 5641								
Air Pressure	ASTM D 5820								
Electric Leak Detection									
Defects and Repairs									

	CQA TEST RESULT EVALUATION								
Media Test Type	Test Method	Spec Rqrmnt	Test Failed Identifier	Failed Test Loc (x,y)	Failed Value	Re-test #	Re-test Loc (x,y)	Re-test Value	Comments
Geosynthetic Clay Liner (GCL)									
Placement/Panel Layout									
Subgrade Prep									
GCL Conformance Testing CQA									
Moisture Content	ASTM D 2216								
Bentonite Mass Per Unit Area	ASTM D 5993								
Index Flux	ASTM D 5887								
Low Permeability Soils Liner									
Construction Testing CQA									
Water Content	ASTM D6938 Nuke Gauge								
	ASTM D2216 Lab Test								
Density	ASTM D6938 Nuke Gauge								
	Lab Test – See Note 1								
Gradation Testing	ASTM D422								
Atterberg Limits	ASTM D4318								
Line of Optimums Evaluation using 3 Proctor technique									
Specific Gravity	ASTM D854								
Modified Line of Optimums Evaluation using 1 Proctor technique									
Degree of Saturation Calculation									
Hydraulic Conductivity with Line of Optimums									

	CQA TEST RESULT EVALUATION								
Media Test Type	Test Method	Spec Rqrmnt	Test Failed Identifier	Failed Test Loc (x,y)	Failed Value	Re-test #	Re-test Loc (x,y)	Re-test Value	Comments
Hydraulic Conductivity without Line of Optimums									
Max loose lift thickness	Such that compacted lift thickness is no greater than length of penetrating feet, tolerance: + 0.0”								
Borrow Source Testing CQA									
Water Content	ASTM D2216								
Atterberg Limits	ASTM D4318								
Percentage Fines	ASTM D422/1140								
Percent Gravel	ASTM D422								
Compaction Curve	ASTM D698								
Hydraulic conductivity	ASTM D5084								
Subgrade Preparation									
Scarification	Should be scarified prior to placement of initial lift of soil liner material.								
Elevation and slope verification	Standard approved survey practices.								
Proof rolling	No more than 2” deflection allowable based on visual observations, or less as needed to meet specified liner compaction density.								
Initial cut and fill to achieve rough base grades									
Grubbing: tree, rock, debris removal	Should include material disposal.								

	CQA TEST RESULT EVALUATION								
Media Test Type	Test Method	Spec Rqrmnt	Test Failed Identifier	Failed Test Loc (x,y)	Failed Value	Re-test #	Re-test Loc (x,y)	Re-test Value	Comments
Survey	Note: unacceptable material in the sub-grade should be detailed in the spec.								
Individual unit survey	Standard approved survey practices.								
Initial boundary survey (existing conditions)	Standard approved survey practices, should establish site-wide and unit specific grid system.								