COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

ELECTRONIC APPLICATION OF KENTUCKY	**)**	
UTILITIES COMPANY FOR A CERTIFICATE	**)**	
OF PUBLIC CONVENIENCE AND NECESSITY	**)**	**CASE NO.**
AND APPROVAL OF AMENDMENT OF ITS 2016	**)**	**2017-00483**
COMPLIANCE PLAN FOR RECOVERY	**)**	
BY ENVIRONMENTAL SURCHARGE	**)**	

KENTUCKY UTILITIES COMPANY

RESPONSE TO THE
COMMISSION STAFF'S FIRST REQUEST
FOR INFORMATION

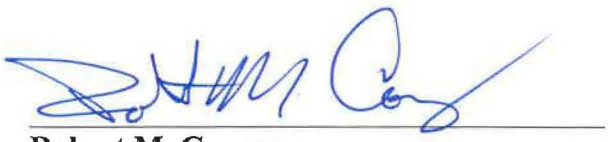
DATED MARCH 8, 2018

FILED: MARCH 26, 2018

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Robert M. Conroy**, being duly sworn, deposes and says that he is Vice President, State Regulation and Rates, for Kentucky Utilities Company and Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.



Robert M. Conroy

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of March 2018.

Notary Public (SEAL)

My Commission Expires:

JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Christopher M. Garrett**, being duly sworn, deposes and says that he is Controller for Kentucky Utilities Company and Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Christopher M. Garrett

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of March 2018.

Notary Public (SEAL)

My Commission Expires:
JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Gary H. Revlett**, being duly sworn, deposes and says that he is Director – Environmental Affairs for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Gary H. Revlett

Gary H. Revlett

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 23rd day of March 2018.

Judy Schooler (SEAL)
Notary Public

My Commission Expires:
JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) **SS:**
COUNTY OF JEFFERSON)

The undersigned, **R. Scott Straight**, being duly sworn, deposes and says that he is Vice President, Project Engineering for Kentucky Utilities Company and Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

R. Scott Straight

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 22nd day of March 2018.

Notary Public (SEAL)

My Commission Expires:
JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) **SS:**
COUNTY OF JEFFERSON)

The undersigned, **Stuart A. Wilson**, being duly sworn, deposes and says that he is Director, Energy Planning, Analysis & Forecasting for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Stuart A. Wilson

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 26th day of March 2018.

Notary Public (SEAL)

My Commission Expires:
JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 1

Witness: R. Scott Straight

Q-1. Refer to the Application, page 5, paragraph 8.

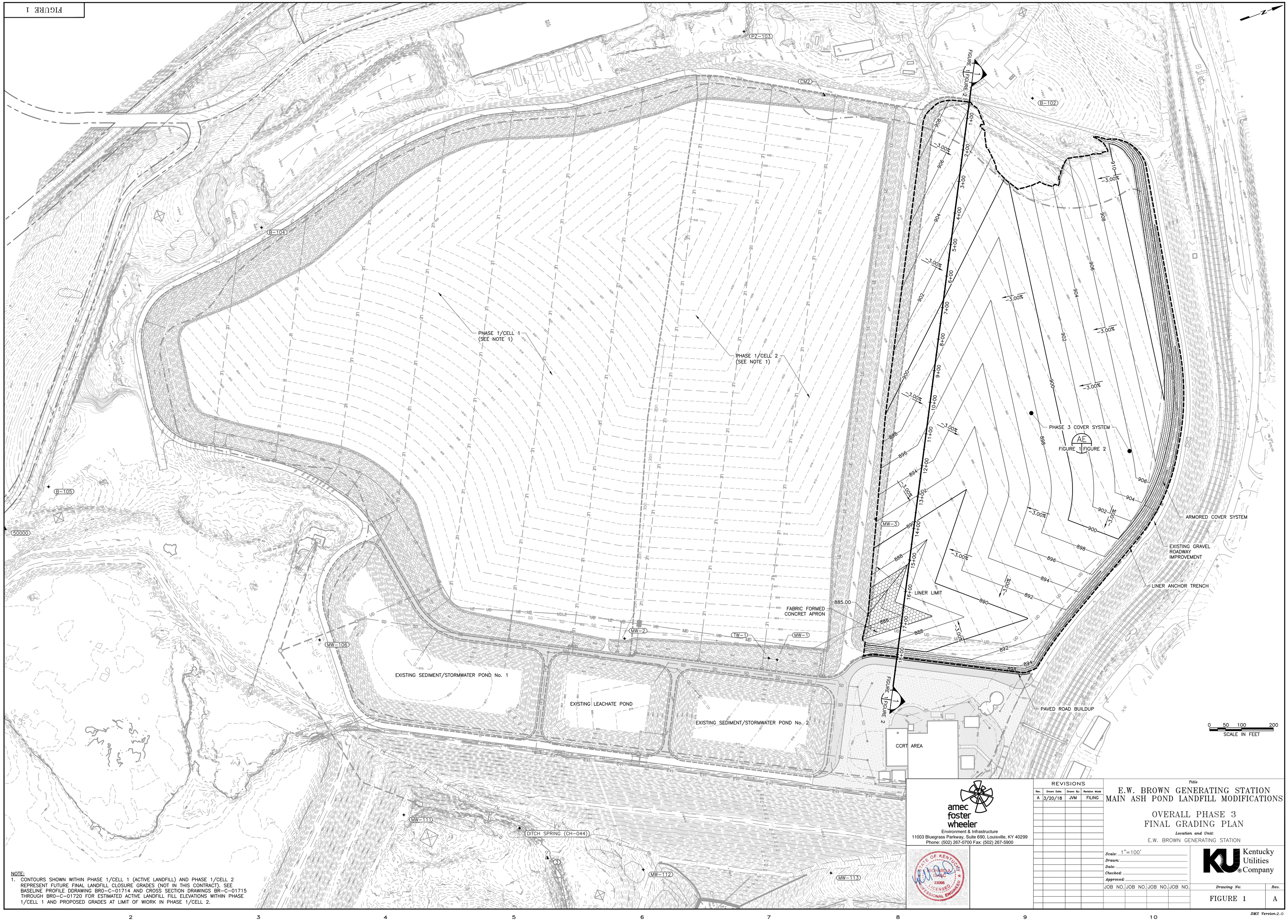
a. Provide the estimated final depth of Coal Combustion Residual ("CCR") material to be placed in the proposed smaller version of Phase II.

b. Provide the height of the remaining surface area after the cap and closure is completed.

A-1. a. As shown in Exhibit RSS-1, the depth of the CCR material in the landfill varies throughout the landfill. The maximum depth based on the highest elevation of CCR material placed is 44 feet.

b. The height of the remaining surface area of the Main Ash Pond that is not overtopped by the landfill varies as shown in the attachment. Nominally the cap and closure system is two feet thick.

FIGURE 1



NOTE:
1. CONTOURS SHOWN WITHIN PHASE 1/CELL 1 (ACTIVE LANDFILL) AND PHASE 1/CELL 2 REPRESENT FUTURE FINAL LANDFILL CLOSURE GRADES (NOT IN THIS CONTRACT). SEE BASELINE PROFILE DDRAWING BR0-C-01714 AND CROSS SECTION DRAWINGS BR-C-01715 THROUGH BR0-C-01720 FOR ESTIMATED ACTIVE LANDFILL FILL ELEVATIONS WITHIN PHASE 1/CELL 1 AND PROPOSED GRADES AT LIMIT OF WIORK IN PHASE 1/CELL 2.

amec foster wheeler
Environment & Infrastructure
11003 Bluegrass Parkway, Suite 690, Louisville, KY 40299
Phone: (502) 267-0700 Fax: (502) 267-5900

STATE OF KENTUCKY
Nicholas Sharp
33095
LICENSED PROFESSIONAL ENGINEER

REVISIONS

Rev.	Drawn Date:	Drawn By:	Revision Made
A	3/20/18	JVM	FILING

Title
E.W. BROWN GENERATING STATION
MAIN ASH POND LANDFILL MODIFICATIONS

OVERALL PHASE 3
FINAL GRADING PLAN

Location and Unit:
E.W. BROWN GENERATING STATION

Scale: 1"=100'
Drawn:
Date:
Checked:
Approved:

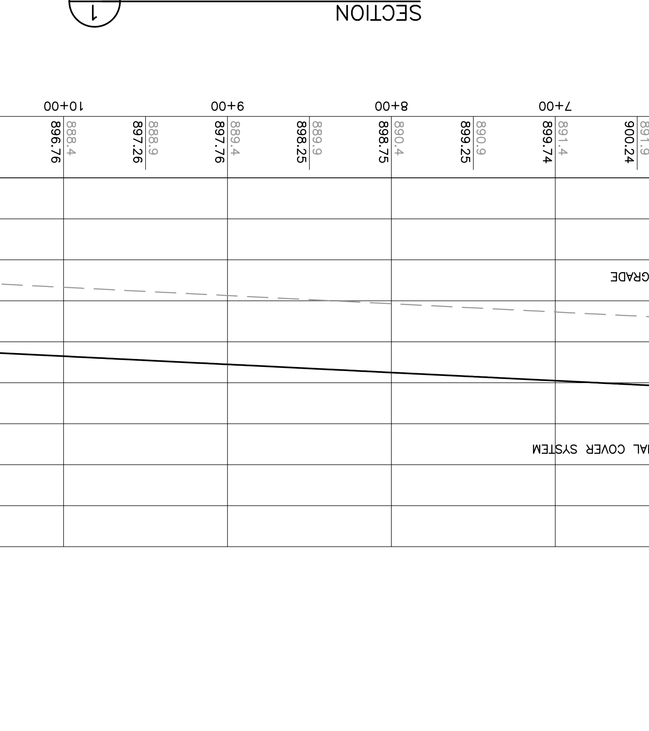
Kentucky Utilities Company

JOB NO.	JOB NO.	JOB NO.	JOB NO.

Drawing No: FIGURE 1
Rev. A

DMS Version 2.0

Attachment to Response to PSC-1 Question No. 1(b)
Page 1 of 2
Straight



PHASE 3 COVER SYSTEM
NTS
AE FIGURE 2

SECTION
SCALE: 1"=50' H, 1"=10' V.
1 FIGURE 2

Rev.	Drawn Date	Drawn By	Revision Made
A	3/20/18	JVM	FILING

REVISIONS

amec foster wheeler
Environment & Infrastructure
11003 Bluegrass Parkway, Suite 690, Louisville, KY 40299
Phone: (502) 267-0700 Fax: (502) 267-5900

COMMONWEALTH OF KENTUCKY
LICENSED
PROFESSIONAL ENGINEER
33058

Title
E.W. BROWN GENERATING STATION
MAIN ASH POND LANDFILL MODIFICATIONS
CIVIL DETAILS 2

Location and Units:
E.W. BROWN GENERATING STATION

Scale: None
Drawn:
Date:
Checked:
Approved:

KU Kentucky Utilities Company

JOB NO. JOB NO. JOB NO. JOB NO. JOB NO.

Drawing No. FIGURE 2 Rev. A

FIGURE 2

DRS Version 2.0

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 2

Witness: R. Scott Straight / Gary H. Revlett

Q-2. Refer to the Application, page 6, paragraph 11. Provide the status of any necessary permit modifications or construction permits.

A-2. KU met with the Kentucky Division of Waste Management ("KDWM") on February 12, 2018. It was determined that a minor modification to the existing landfill permit is required to effectuate the changes proposed in this application. The application for a permit modification was submitted on March 21, 2018 and is provided as an attachment to this response. Based on discussions with KDWM, KU expects approval within six months after submittal. No additional permits are expected to be needed for the amended Phase II and Main Pond cap and closure project.

March 16, 2018

Mr. Danny Anderson
Solid Waste Branch Manager
DEP Division of Waste Management
300 Sower Blvd., 2nd Floor
Frankfort, KY 40601
502-564-6716 (Telephone)
502-564-4245 (Fax)
Danny.anderson@ky.gov

Subject: Application for Minor Modification to a Formal Special Waste Permit
Permit sw-0840010
Harrodsburg, Mercer County KY
Amec Project No. 567530031

Dear Mr. Anderson:

Amec Foster Wheeler on behalf of Kentucky Utilities (KU), is submitting this application to modify Special Waste Landfill permit sw-0840010 at the E.W. Brown Generating Station (Station) in Mercer County, KY. We are requesting 3 changes to the permit by this modification.

Change #1 Since the original landfill permit was issued, the projected volume of CCR generated by the Station has been reduced, necessitating the changes to the landfill design and the permit addressed by this application. This application for permit modification is based on a reduced landfill footprint, lowered cap grades and consolidation of the landfill. These changes are described in further detail in PM Attachment 2. Landfill phasing nomenclature between the original permit and this permit modification have changed as described below.

Original Landfill Phasing	Permit Mod
Phase 1	Cell 1
Phase 2	Cell 2
Phase 3	Phase 3 Closure Area

Change #2 Shortly after the construction permit issue date, KU was required to provide a $3 million Surety Bond (Instrument No. 106094008) to address 6.88 acres of the former Main Ash Pond which at that time was not covered (all other portions of the former Main Ash Pond were covered and closed). The bonded area included future road construction and the Coal Combustion Residual Treatment Material Handling (CCRT) area. Presently, the construction of these facilities has been completed (PM Attachment 7) and all 6.88 acres that were subject to the $3 million bond are now covered with impervious roadway pavements in accordance with the provisions of the permit or with CCRT Area buildings. Since the closure obligation associated with this 6.88-acre area has been completed, KU requests the $3 million surety bond, issued by Travelers, be released and returned.

Continued…

Change #3 We request the permit special condition, requiring landfill operations to place CCR material such that "adjoining phases shall not differ in thickness by more than ten (10) feet", be removed from the modified permit. The special conditions section is copied below.

Variances, Alternate Specifications and Special Conditions:

1. Operation: Wastes shall be placed uniformly across the landfill. With the exception of the first layers used to fill in the sawtooth valleys, the waste shall be placed across the landfill in even layers no greater than ten (10) feet thick. The owner or operator shall place waste in thin lifts and adjoining phases shall not differ in thickness by more than ten (10) feet. Waste shall be placed only on constructed and approved liner. Waste shall be sloped to allow for proper drainage. This pattern of uniform loading across the landfill shall continue until final volume and slopes are achieved. [401 KAR 45:140 Section 2]

A stability evaluation of the landfill under Incremental 10 foot lifts of CCR is provided in PM Attachment 6 to support this request.

Closing

The modified landfill design will significantly improve the cover over the landfill and the old Main Ash Pond. The revised cover will now include a Linear Low Density Polyethylene membrane (LLDPE) over the entire old Main Ash pond with an additional Geocomposite Clay membrane over the old Phase 3 portion of the landfill. The bottom liner under the revised landfill footprint will remain unchanged from the permitted liner. Landfill design drawings are presented in PM Attachment 3.

To assist in the evaluation of the requested changes we have prepared a (PM Attachment 1) that lists the original permit sections, the associated landfill permit attachment numbers and whether that section was changed by this permit modification.

Per 401 KAR 45:250, we have enclosed a check for $500 (PM Attachment 5), and a signed certification by Jeffrey Fraley, General Manager of the Station (PM Attachment 4). If you have any questions concerning this application, please contact Paul Puckett with KU or myself.

Sincerely
Amec Foster Wheeler

Mark J. Schuhmann PE
Senior Principal

John W. Storm PE
Project Manager

cc: Paul Puckett - KU

Permit MOD (PM) Attachments:
PM Attachment 1 - Table of Landfill Permit Changes
PM Attachment 2 - Description of Permit Modification
PM Attachment 3 - Landfill Modification Drawings
PM Attachment 4 - Form DEP 7017 (6/10)
PM Attachment 5 - Application Fee Check ($500)
PM Attachment 6 - Landfill Stability Evaluation
PM Attachment 7 - Photos of Bonded Area Construction
PM Attachment 8 - Cover Specifications
PM Attachment 9 - Geotechnical Instrumentation

PM Attachment 1 - Table of Landfill Permit Changes

PM Attachment 1
Table of Landfill Permit Changes

Form 7094A (5/92)			Volume	2016 Permit Attachment	2016 Appendix	Comment	Same as Permit	Item Modified
A		General Information	1					
	1	Applicant					x	
	2	Facilty Name					x	
	3	Facility Operator					x	
	4	Property Owner		**1**		Additional Property Owners	x	
	5	Mineral Rights		**2**			x	
	6	Existing landfill Mod type				See Form 7094A (PM Attachment 4)		x
	7	Adjacent Property Owners		**3**		List of Adjacent Property Owners	x	
	8	Property Deed, Lease ROE		**4**		Copy of deed or lease	x	
	9	Impact on transportation routes		**5**		Description of Impact	x	
	10	Variances		**6**		List of variances applied for	x	
	11	Zoning Compliance		**7**		Notarized Statement from applicable jurisdiction	x	
	12	Fire District Assistance		**8**		Description of Local Assistance	x	
B	**1**	Legal Entity						
	2	Registration with KY Sec. of State					x	
	3	Key Personnel Past Performance		**9**		DEP Form 7094J	x	
C		Operational and Permit Information						
	1	Waste Information		**10**		Waste Sources and Amounts (PM Attachment 2)		x
	2	Industrial Information						
				11		Raw Material List	x	
				12		Waste Characteristics (TCLP)	x	
	3	Equipment List		**13**		Equipment list	x	
D		Siting Information						
	1	Directions to site					x	
	2	Site Location and nearest features					x	
	3	USGS Quad		**14**		USGS Quad with 1 mile radius	x	
	4	Site Map		**15**		Site map with boundaries and features	x	
				16		Map with archeological site	x	
				17		Map with crital habitats	x	
				18		Map with wetlands	x	
	5	County Map		**19**		County Highway Map	x	
E		Design Plans	2					
	1			**20**		Site Map: current conditions, buffer zones, and monitor	x	
	2					Site Plans Development (PM Attachment 3)		x
	3					Cross sections (PM Attachment 3)		x
	4					Profile along baseline (PM Attachment 3)		x
	5					Development with sequence of filling (PM Attachment 3)		x
	6					Construction Details (PM Attachment 3)		x
	7					Details of lifts, liners, final cover (PM Attachment 3)		x
F		Narrative	3					
	1	dist to perennial stream		**21**		Water Quality Certificate	x	
	2	Site distance to features					x	
	3	Seasonal Groundwater table					x	
	4	Leachate with metals					x	
	5	Flood plain		**22**		Desciption how to meet 401KAR 30:031	x	
	6	Holocene Displacement					x	
	7	Surface Water Controls		**23**		Description of Surface Water Controls	x	
	8	Gas emission potential		**24**		Explosive gas monitoring system	x	
	9	Public Access	3	**25**		Controls to limit public access	x	
	10	Working Face		**26**		Methods employed for woking face	x	
	11	Signage					x	
				27		Bottom Liner Specifications	x	
			4	**28**		Bottom Liner Risk analysis	x	
					A	Help Models	x	
					B	Leachate Pipe Design	x	

PM Attachment 1
Table of Landfill Permit Changes

Form 7094A (5/92)			Volume	2016 Permit Attachment	2016 Appendix	Comment	Same as Permit	Item Modified
					C	Leachate Pond	x	
					D	Liner Design	x	
					E	Protective Cover Design (PM Attachment 3)		x
					F	Geotechnical Analysis (PM Attachment 6)		x
					G	Previous Subsurface Explorations	x	
					H	Boring Logs and Laboratory, 1973	x	
					I	Boring Logs and Laboratory, 1989	x	
			5		J	Boring Logs and Laboratory, 2006	x	
					K	Design Report: 2007	x	
					L	Main Ash Pond Construction Plans	x	
					M	As-Built Dwngs 2008	x	
			6		N	Gypsum Dewatering 2007	x	
					O	Limestone Prep 2007	x	
					P	FGD Duct 2010	x	
					Q	Coal Pile 2010	x	
					R	Unit 3 SCR 2010	x	
					S	Left Abut. Exploration 2011	x	
					T	Subsurface Exploration 2011	x	
					U	Scrubber 2006	x	
					V	Piez. and Settlement Monitoring (PM Attachment 9)		x
H	Geologic and Hydrogeologic Information							
1	Soil Profile		7	**29**		Unconsolidated Material Description	x	
2	Regional Bedrock Geology						x	
3	Site Specific Geology						x	
4	Fracture Zones			**30**		FZ influence on groundwater movement	x	
5	Geologic Cross Sections			**31**		2 Cross sections	x	
6	Coal			**32**		List of coal seams	x	
7	Mine			**33**		List of coal mines within 1500 feet	x	
8	Rock core logs			**34**		Boring logs	x	
9	Geology map			**35**			x	
10	Hydrogeologic Chacterization			**36**		Hydrogeologic chacterization report	x	
				37		map of springs and upgradient wells	x	
I	Soils Information							
1	Soil description			**38**		Unconsolidated zone cross section	x	
2				**39**		Borrow soil inventory	x	
3				**40**		Borrow soil inventory by soil type	x	
J	Construction Quality Control Plan							
1	CQA Plan			**41**			x	
K	Recordkeeping and Reporting			**42**		Recordkeeping and Reporting System	x	
L	Surface and Groundwater Corrective Action							
1				**43**		Surface water monitoring plan	x	
				43A		location of surface water monitoring points	x	
2	Groundwater Monitoring Plan			**44**		Groundwater Monitoring Plan	x	
				44A		Proposed well locations and depths	x	
M	Closure, Closure Care and Performance Bond							
				45		Closure cap specifications (PM Attachment 8)		x
				46		Final Cover System Risk Analysis	x	
				47		Closure Plan	x	
				48		Post-Closure Plan	x	
N	Permit Preparation Information					See Form 7094A (PM Attachment 4)		x
O	Public Notice			**49**		Draft meeting notices (PM Attachment 4)		x
				50		Draft meeting notices	x	
P	Certification					(PM Attachement 4)		x

PM Attachment 2 - Description of Permit Modification

PM Attachment 2 – Description of Solid Waste Landfill Permit Modification

Summary and Purpose

The purpose of this application is to modify Solid Waste Landfill Permit No. **sw08400010,** issued on 09 September 2016 for the Special Waste landfill at the E.W. Brown Generating Station (Station) operated by Kentucky Utilities Company (KU) near Harrodsburg, KY. The permitted landfill design was based on anticipated production volumes of Coal Combustion Residuals (CCR) from three coal-fired generating units for the expected life of the Station. Since the permit was issued, KU has decided that Units 1 and 2 will be retired in early 2019. Retiring these units will substantially reduce the volume of coal burned, the CCR materials generated at the Station, and consequently the volume of CCR that will be placed in the landfill.

Amec Foster Wheeler was retained by KU to design a reduction to the landfill volume from 8.5 Million Cubic yards (MCY) of CCR to 2.5 MCY as a result of retirement of Units 1 and 2. The landfill design changes have resulted in reductions of: the landfill footprint, the height of the landfill when completed and the slope of the cap.

The reduced landfill footprint has been combined into a single landfill phase (Phase 1) with two cells. The area nomenclature between the original permit and this MOD are described below:

Original Landfill Phasing	Permit Mod
Phase 1	Cell 1
Phase 2	Cell 2
Phase 3	Phase 3 Closure Area

The area previously designated for Phase 3 of the landfill is now outside the modified landfill footprint and is designated as Phase 3 Closure. The modified design will significantly improve the cover over the landfill as well as the Phase 3 Closure area. The revised cover will provide a vegetated cover, underlain by a Linear Low Density Polyethylene membrane (LLDPE) over the entire old Main Ash Pond with an additional Geocomposite Clay Liner (GCL) within the Phase 3 Closure area. The bottom liner under the revised landfill footprint will remain unchanged from the permitted liner. The revised cover systems are described below in further detail.

The modified cap designs will provide a landfill with the flexibility to account for changes in CCR volumes produced for the remaining life of coal-fired generation at the Station, while completing efforts to cap the old Main Ash Pond. The overall height of the revised landfill design has been reduced nearly 50 feet from the permitted height. As shown on the drawings (PM Attachment 3), the peak elevation of the completed landfill will be lowered from the original permit design elevation of approximately 981 feet to an elevation of 936 feet.

The changes to the permitted landfill are summarized in the Table 1 below:

Table 1 – Proposed Landfill Modifications

No.	Feature	As Permitted	This Modification	Reduction %
1	**Landfill Area, Total (Ac.)**	107.6	73.6	31
2	**Landfill Volume, Total (MCY)**	8.6	2.5	71
3	**High Point Elevation, Final Cap**	981	936	-
4	**Maximum Landfill Depth, Ft**	91	43	50
5	**Cover Slope %** **Side Slopes** **Top**	33% 5%	25% 3%	24 40

The modified (reduced) landfill size reduces the overall height of landfill, reduces potential view shed considerations, and allows for the flexibility to repurpose the Stormwater/Sedimentation Pond 2 and the Leachate Pond, should the need arise. This modification also provides the necessary airspace margin to accommodate additional CCR storage if necessary during the life of coal-fired generation at the Station.

Landfill Bottom Liner System

The bottom liner design under the landfill (Cell 1, Cell 2) is not changed by this permit modification. The landfill bottom liner detail is shown on Drawing C-01708, Detail M, in PM Attachment 3 to this application.

Phase 3 Closure-Vegetated Cover System

The permitted cover system for Phase 3 consisted of a 24 inch thick soil cover placed on a 5% slope. That cover system has been improved under this permit modification. The modified Phase 3 Closure cover section is shown Drawing C-01708, Detail AE, in PM Attachment 3. The modified cover system includes from top to bottom:

- 6 inch thick layer of vegetated topsoil
- 18 inch thick layer of cover soil
- Geocomposite Drainage Layer (GDL)
- 40 mil textured LLDPE (linear low density polyethylene) FML geomembrane
- Geosynthetic Clay Layer (GCL)
- Cushion Geotextile Type II

The revised cover for the Phase 3 Closure area is similar to the Landfill cover design but is enhanced with the addition of a Geosynthetic Clay layer and a Cushion geotextile. The entire footprint of the old Main Ash Pond will now be protected with a low permeability FML cover. The Phase 3 Closure cover slopes have also been flattened from the permitted slope to the modified 3%. This revised cover should nearly eliminate the infiltration of rainwater into Phase 3 Closure area.

Landfill-Vegetated Cover System

The permitted landfill cover system consisted of a 24 inch thick soil cover placed on a 5% slope. That cover system has been improved under this permit modification. The modified cover section is shown Drawing C-01708, Detail H, in PM Attachment 3 and includes from top to bottom:

- 6 inch thick layer of vegetated topsoil
- 18 inch thick layer of cover soil
- Geocomposite Drainage Layer (GDL)
- 40 mil textured LLDPE (linear low density polyethylene) FML geomembrane

The revised cover will be placed over landfill Cell 1 and Cell 2. The landfill cover slopes have also been flattened from the permitted slope to the modified 3% slope. This revised cover will substantially reduce the infiltration of rainwater into the landfill area and after closure significantly reduce the generation of leachate. The specifications for the new cover are provided in PM Attachment 8.

Leachate Collection System

The permitted leachate collection system and leachate pond was sized for a landfill of 107.6 Ac which incorporated three phases of construction. This modified design reduces the landfill footprint size by 30 percent to 73.6 Ac. The permitted leachate collection system design has not been altered for the revised landfill areas Phase1-Cell1 and Phase1-Cell 2. A leachate collection system is not required under the Phase 3 closure area as it is no longer within the landfill footprint.

Stormwater Collection System

The stormwater runoff collection system has not been altered by this Permit Modification. However, the height of the landfill has been reduced 45 feet and the cover slopes are flatter than the permitted design. The total volume of stormwater runoff generated by Cell 1 and Cell 2 will be essentially the same as that calculated by the permitted design however the peak flow rate will be reduced since the final cover grades are flatter. The runoff from the former Phase 3 Area which is outside the footprint of the modified landfill, will still be directed to the north stormwater pond (pond 2). Stormwater piping sizes are not changed by the modified design, however the pipes as well as the existing stormwater ponds are now oversized for the updated runoff design.

10 Foot Maximum Height Differential

The 2016 permit for construction and operation of the landfill contained the following special condition.

Variances, Alternate Specifications and Special Conditions:

1. Operation: Wastes shall be placed uniformly across the landfill. With the exception of the first layers used to fill in the sawtooth valleys, the waste shall be placed across the landfill in even layers no greater than ten (10) feet thick. The owner or operator shall place waste in thin lifts and adjoining phases shall not differ in thickness by more than ten (10) feet. Waste shall be placed only on constructed and approved liner. Waste shall be sloped to allow for proper drainage. This pattern of uniform loading across the landfill shall continue until final volume and slopes are achieved. [401 KAR 45:140 Section 2]

KU is requesting that this restriction be removed. The modified landfill design will be 45 feet lower in elevation than the permitted thickness, the modified design cover slopes are much flatter than the permitted cover slopes (3% vs 5%), the final cover will be much less permeable than the permitted design (with the inclusion of a FML in the cover). These factors combine to result in a more stable final landfill slope configuration than the permitted landfill design.

The stability of CCR placement with height differentials greater than ten (10) feet were evaluated in our supplemental stability evaluation (PM Attachment 6). This analysis assumed 40 feet of landfilled CCR placed above the Main Ash Pond CCR, in10-foot thick increments. Each increment was placed in one day, with 59 days before placement of the next increment (240 days to place 40 feet of CCR). The analysis used conservative assumptions to model the buildup of pore water pressure in the ponded CCR, due to rapid placement. The analysis resulted in a minimum factor of safety of 1.6 under this loading case and is described further in PM Attachment 6. The piezometer monitoring data summarized in PM Attachment 6 indicates the water levels in the Main Ash Pond continue to drop with time, continuing to trend towards further enhancement in stability of the landfill slopes.

PM Attachment 3 - Landfill Modification Drawings

PM Attachment 4 - Form DEP 7017 (6/10)

Form DEP 7017
Certification Page
Public Meeting Notice Form

ENERGY AND ENVIRONMENT CABINET

DEPARTMENT FOR ENVIRONMENTAL PROTECTION
DIVISION OF WASTE MANAGEMENT
200 FAIR OAKS LANE, SECOND FLOOR
FRANKFORT, KY 40601
TELEPHONE NUMBER 502-564-6716

Application for a Minor Modification To a Formal Solid Waste Permit Form DEP 7017 (6/10)

Statutes and regulations may be viewed online at the following website address: http://www.lrc.ky.gov/search.htm

Solid waste application forms are available at the following website address: http://www.waste.ky.gov

DWM OFFICAL USE ONLY

AI#: _____ **Application #:** _____

GENERAL INSTRUCTIONS

1. **APPLICABILITY – This form must be completed and submitted to the Cabinet by persons who propose to apply for a minor modification of a formal permit.**

2. **ASSISTANCE – Questions regarding this form may be directed in writing to the Division of Waste Management (DWM), Solid Waste Branch at the address listed above, or by calling 502-564-6716.**

3. **SUBMISSION – Please type or print legibly in permanent ink. Submit the original and two (2) copies of the completed form to the DWM at the address listed above. If an item is not applicable, write "N/A" in the space provided.**

4. **FEES - Applicants must submit the appropriate filing fee at the time of application submittal in accordance with 401 KAR 47:090, Section 2.**

5. **LAWS AND REGULATIONS – Applicants are expected to understand and comply with all laws and regulations applicable to the facility.**

To assist you in the submittal of a complete and accurate application, the Division has identified the most common errors found during the review process. These errors are listed below for your convenience.

1. **Failure to provide the appropriate fee. See 401 KAR 47:090, Section 2. (6)(a).**

2. **Failure to complete the application.**

3. **Failure to comply with public notice requirements. See KRS 224.40-310 and 401 KAR 47:140, Section 7 for more information.**

4. **Failure to comply with Financial Assurance requirements. If the existing financial assurance is insufficient to fully cover current closure and post-closure costs, updates will be required.**

5. **Failure to properly sign and notarize the application. An individual with signature authority for the applicant as defined by KRS 224.01-010(44) and 401 KAR 47:160 must sign and notarize the appropriate signature sections of the application.**

6. **Failure to provide appropriate, fully completed attachments. Maps, drawings, narratives or any attachments that lack sufficient detail or drawings that are not signed, dated and sealed by a professional engineer or geologist may cause delays in the review and approval of the application.**

Warning! Due to the potential for identity theft, do not provide social security numbers to the DWM as part of this application. If this information is required during the normal course of review of the application, a cabinet representative will contact the appropriate individual to acquire this information in a secure format.

Application for a Minor Modification to a Formal Solid Waste Permit

General Information

1. Agency Interest #: 3148 **2.** Permit #: sw - 08400

3. Fee submitted: **$** 500. **4.** Check or Money Order #:

5. Method of payment:
- ☒ Check
- ☐ Money Order
- ☐ Cash
- ☐ Exempt (Publicly Owned Facility)

Applicant Information

6. Permittee Name: Kentucky Utilities Co - E.W. Brown Station

(This refers to the corporation, LLC, business, person, government agency, etc., that owns or operates the facility.)

7. Permittee Mailing Address: 220 West Main Street

8. City: Louisville **9.** State: KY **10.** Zip Code: 40202

11. Contact Person: Paul Puckett **12.** Title: Sr. Engineer

13. E-mail Address: Paul.Puckett@lge-ku.com

14. Phone #: 502 - 627 - 4659 ext.

15. Cell #: 502 - 648 - 7842 **16.** Fax #: 502 - 217 - 4836

Facility Information

17. Facility Name: Kentucky Utilities - E.W. Brown Generating Station
18. County: Mercer

19. Facility Location: 815 Dix Dam Road
(Provide the street or physical location. Do not use P. O. Box #'s, etc.)

20. City: Harrodsburg **21.** Zip Code: 40330

22. Facility Contact: Jeff Fraley **23.** Title: General Manager

24. E-mail Address: jeffrey.fraley@lge-ku.com

25. Phone #: 859 - 748 - 4411 ext.

26. Fax #: - - **27.** Cell #: - -

Preparer Information

(Complete items 28 – 37 if the following information concerning the person preparing this application is different from the contact persons named in items 11 and 22.)

28. Preparers Name: Mark J. Schuhmann **29.** Company: Amec Foster Wheeler

30. Mailing Address: 11003 Bluegrass Parkway Suite 690

31. City: Louisville **32.** State: KY **33.** Zip Code: 40299

34. E-mail Address: mark.schuhmann@amecfw.com

35. Phone #: 502 - 471 - 2332 ext.

36. Cell #: 502 - 609 - 1189 **37.** Fax #: 502 - 267 - 5900

Attachments and Descriptions

38. Type of modification you are seeking:

- ☐ A vertical expansion of less than two (2) years
- ☐ A Groundwater Assessment Plan
- ☐ A Groundwater Corrective Action Plan
- ☐ A modification to the Groundwater or Surface Water Monitoring Plan
- ☐ A modification to the sediment pond design
- ☐ A modification to the alternate daily cover
- ☐ A modification to the leachate collection system
- ☐ A modification to the Closure Plan
- ☐ A modification to change the name of the owner or facility
- ☐ A modification to change the closure or post closure cost estimate
- ☐ A modification to change the permit boundary other than waste boundary
- ☒ Other (describe): Reduction in the landfill size from 107.6 Ac to 73.6 Ac due to reduction in volume needed from 8.6 million cubic yards (MCY) to 2.5 MCY , Reduction in landfill top elevation from elevation 981 feet to 936 feet, Consolidation of three (3) permitted phases to one (1) combined phase. Requesting removal of permit

requirement to limit CCR lift thickness to no greater than 10 feet of CCR between phases of landfill.

39. Provide, as **Attachment 1,** a detailed description of the permitting action you are seeking.

40. Provide, as **Attachment 2,** appropriate drawings, calculations, maps, cross-sections, etc.

Certification

41. Pursuant to 401 KAR 47:160, Section 6, a person with signature authority such as a sole proprietor, owner, partner, corporate officer, plant manager, LLC member, mayor, county judge executive or other authorized official must sign this certification statement.

NOTE: Consultants may not sign the following certification statement.

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for such violations."

Name of Person Signing (type or print): Jeffrey Fraley

Title of Person Signing: General Manager Date: 3-15-2018

Signature per 401 KAR 47:160: Jeffrey A. Fraley

Subscribed and sworn to before me this 15 day of March, Year 2018

Notary Public Signature:

State of Ky County of Mercer My commission expires: March-11-2019

Kentucky UNBRIDLED SPIRIT

DEP 7094A (5/92)

PUBLIC NOTICE

Pursuant to Permit number: SW-0840010

The Energy and Environment Cabinet, Division of Waste Management has received a Application for Minor Modification to a Formal Special Waste Permit from:

Name of Applicant: Kentucky Utilities Co.

Name of Facility: E.W. Brown Station
Address: 815 Dix Dam Road
City: Harrodsburg State: KY Zip Code 40330

This application, if approved, would allow Minor Modifications to a Formal Solid Waste Permit to construct a landfill to accept the following types of waste and the following activities: Coal Combustion Residuals (CCR) consisting of fly ash, bottom ash, and scrubber sludge generated by the E.W. Brown Generating Station.

The proposed facility may be accessed from Harrodsburg, KY
by traveling on US 68 east to Shakertown, then on Shakertown Road south to Dix Dam Road to Station.

Additional information regarding this application may be obtained from:

Contact Person: Paul Puckett
Address: 220 West Main Street
City Louisville, State: KY Zip Code: 40202

Phone No. (502) 627-4659

DEP 7094A (5/92)

The permit application is being processed at the following location:

Division of Waste Management
Solid Waste Branch
200 Fair Oaks
Frankfort, KY 40601

Within thirty (30) days of the publication of this notice, any person who wishes to comment on the application may submit written comments, and, if desired, request from The Cabinet a public meeting.

Please refer to Agency Interest ID# No. 3148

and Solid Waste Permit No. sw08400010 County: Mercer

on all Correspondence.

Publication pursuant to KRS 224.40-310.

PM Attachment 5 - Application Fee Check ($500)

PM Attachment 6 - Landfill Stability Evaluation

PM Attachment 6 – Landfill Stability Evaluation

Introduction

LG&E-KU Services Company's (KU) applied for a special waste landfill permit at the EW Brown Generating Station (Station) on August 8, 2011. The permit would allow KU to construct a 100-acre, 3-phased landfill above the Main Ash Pond at the site.

The permit application was accepted as Permit No. 084-00010. As part of the construction permit the Division of Waste Management (DWM) stipulated that the height of new Coal Combustion Residuals (CCR) placed in the landfill must be placed across the landfill in even layers no greater than 10 (ten) feet thick, and adjoining phases shall not differ in thickness by more than 10 (ten feet.

As part of the permit application approval, global stability analysis was previously performed along 3 critical analysis sections (AA', BB', and CC').

Several changes to power generation has occurred since the permit was issued resulting in a significant reduction in expected CCR volume. As a result, the landfill was redesigned, resulting in a reduced footprint, height, and cap slope. Furthermore, the reduced landfill footprint was combined into a single landfill Phase, with two cells; the revised Phase 1 (Cell 1) encompasses the previous Phase 1 area. The revised Phase 1 (Cell 2) encompasses nearly all the previous Phase 2 area, and the area previously designated for Phase 3 of the landfill is now outside the modified landfill footprint and is designated as Phase 3 Closure.

KU agreed to install a "geotechnical monitoring system" to monitor and measure changes in pore-water pressure and settlement within the existing CCR below the new landfill, during new CCR material placement. Amec Foster Wheeler designed and installed a monitoring system consisting of nested piezometers with companion settlement measuring devices within the landfill footprint (PM Attachment 9). Subsequent to installing monitoring devices in Phase 1, a 12-feet tall starter berm was constructed between Cell 1 and Cell 2. Approximately 3 to 10 feet of new CCR was placed in Cell 1, since the starter berm was constructed.

In conjunction with the geotechnical monitoring devices installed for the landfill, KU agreed to install monitoring devices for a "test pad" located on the north side of the landfill. The purpose of the test pad was to observe the settlement and increased pore-water pressure response of the existing CCR material resulting from the placement of gypsum, stockpiled for landfill construction.

Amec Foster Wheeler created a finite element (FE) computer model of the test pad to predict the settlement and excess-pore-water pressures (EPWP) caused by placement of the gypsum fill. The

predicted settlement and EPWP of the modeled existing CCR was compared to the results measured from our monitoring devices within the test pad. This study was published by Amec Foster Wheeler, as a conference paper titled, *"Geotechnical Instrumentation to Measure Pore-water Pressure and Settlement of an Ash Pond due to Construction of an Ash Landfill"*, submitted to the World of Coal Ash (WOCA) in 2015. Relevant sections of the published study are presented, as they pertain to this report.

Purpose

The purpose of this report is to 1) provide a summary of the geotechnical monitoring data collected as CCR materials were placed in the landfill, 2) perform a pore-water pressure evaluation, which includes modeling an incrementally placed 40 feet high embankment of new CCR placed on the existing landfill liner, which exceeds a surface elevation differential of more than 10 feet, and 3) evaluate the stability of the revised landfill geometry.

Data collected from the results of our geotechnical monitoring system installed beneath the test pad was used to select the best analysis type and hydraulic parameters appropriate for the pore-water pressure evaluation and stability analysis models.

By presenting both the data collected from our monitoring devices, and the results from our pore-water pressure and stability analysis, we intend to demonstrate excess pore-water pressure does not develop to a critical level, new CCR may exceed a surface differential of 10 feet, and the proposed landfill configuration will be stable.

Geotechnical Monitoring System

The geotechnical monitoring system is discussed in PM Attachment 9. The locations of our monitoring system instruments are shown on Plate 1, attached to PM Attachment 9. Monitoring devices were installed in Phase 1 of the landfill, in cell 1 ("A" through "D"), cell 2 ("E" through "H"), and the Test Pad, Phase 3 ("J").

Test Pad Device Installation Data

The test pad area was used to temporarily stockpile gypsum for landfill construction. Shallow and deep piezometer and settlement plates were installed in May 2014 and readings were collected up to January 2015. As of January 2015, approximately 21 feet of gypsum was placed over and around the instrumented area. The monitoring system installation data for the test pad is summarized in Tables 1 and 2, below.

Table 1 – Summary of Piezometer Installation Data for the Test Pad

Landfill Area	Name	Piezometer Range	Piezometer Surface Elevation (feet)	Depth (feet)	Piezometer Instrument Elevation (feet)
Phase 3 (Test Pad)	J	Shallow	882.77	12.14	872.2
		Deep		23.6	860.8

Table 2 – Summary of Settlement Installation Data for the Test Pad

Landfill Area	Name	Settlement Plate Surface Elevation (feet)	Depth (feet)	Bedrock Depth (feet)	Bedrock Elevation (feet)
Phase 3 (Test Pad)	J	882.77	12.14	33.57	849.20

Phase 1 Landfill Monitoring Device Installation Data

The monitoring system installation data for Phase 1 is summarized in Tables 3 and 4, below.

Table 3 – Summary of Piezometer Installation Data for Phase 1

Landfill Area	Piezometer Name	Piezometer Range	Piezometer Surface Elevation (feet)	Depth (feet)	Piezometer Instrument Elevation (feet)
Phase 1 (Cell 1)	A	Shallow	890.1	8.0	882.1
		Deep		41.8	848.3
	B	Shallow	881.2	15.01	866.2
		Deep		38.0	843.2
Phase 1 (Cell 1/ Cell 2 Interface)	C	Shallow	890.1	31.9	858.2
		Deep		55.4	834.7
	D	Shallow	882.5	22.15	860.3
		Deep		42.3	840.2

Table 4 – Summary of Settlement Installation Data for Phase 1

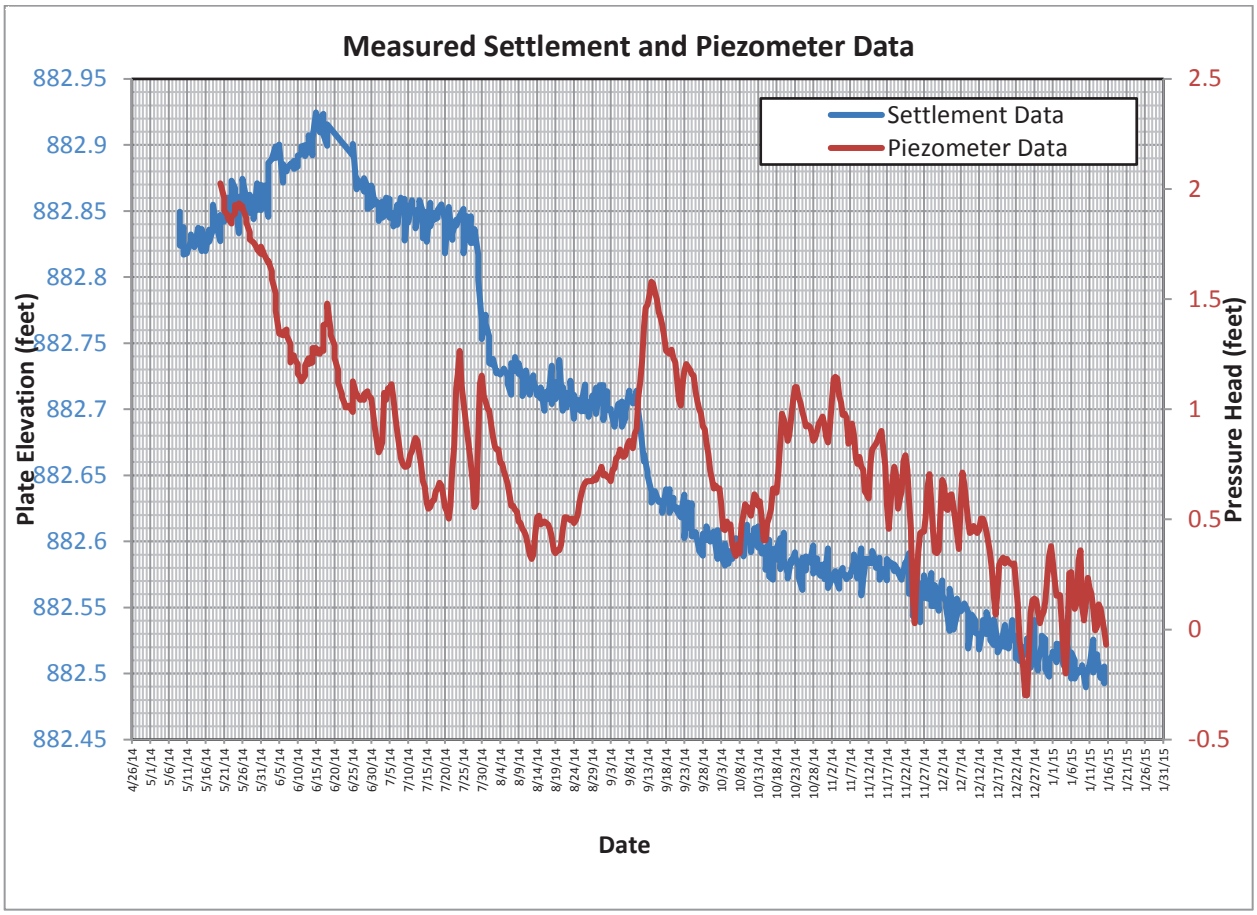
Landfill Area	Plate Name	Settlement Plate Surface Elevation (feet)	Depth (feet)	Bedrock Depth (feet)	Bedrock Elevation (feet)
Phase 1 (Cell 1)	A	890.1	8.0	51.67	838.43
	B	881.2	15.01	48.06	833.14
Phase 1 (Cell 1/ Cell 2 Interface)	C	890.1	31.9	70.37	819.73
	D	882.5	22.15	52.33	830.17

Field Monitoring Device Results

The following subsections present the piezometer and settlement graphs for the devices located within the test pad area and Phase 1 area of the Landfill. Conclusions based on the field monitoring devices are presented later in this report.

Test Pad Monitoring Device Results

Readings from the test pad monitoring devices were recorded over the course of approximately 8 months. The measured field results for the test pad ("J") are shown in Graph 1, below. The pressure head readings (above the instrument) are shown on the right side of the graph and settlement plate elevation on the left vertical axis. The piezometer data was plotted from the deep piezometer; the shallow piezometer, indicated no water level was present. Note, that the elevations for the settlement plate on the vertical axis, are not relevant to the piezometer data points and the pressure head is independent of the settlement plate elevations.

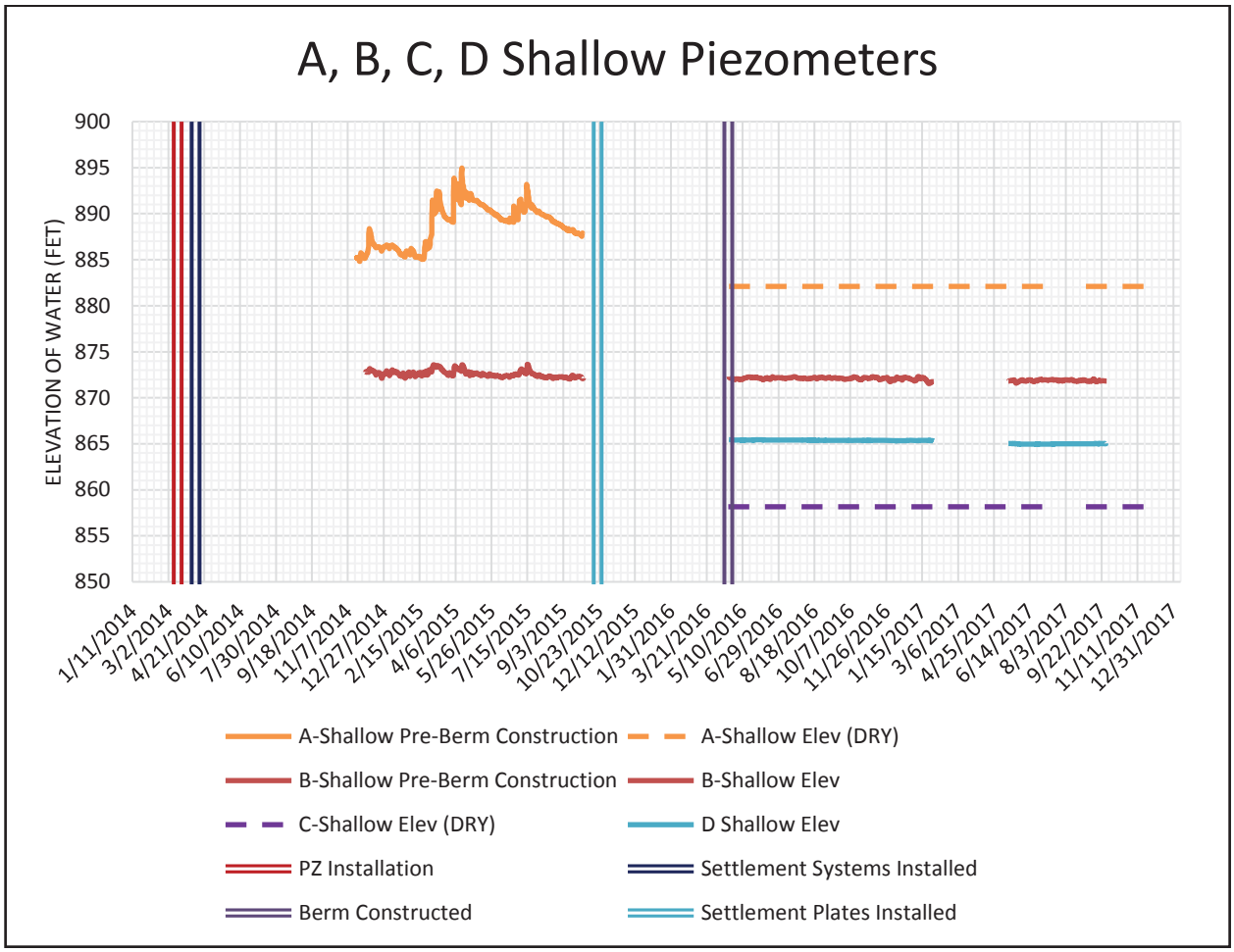


Graph 1 – Summary of Settlement and Piezometer Results for the Test Pad

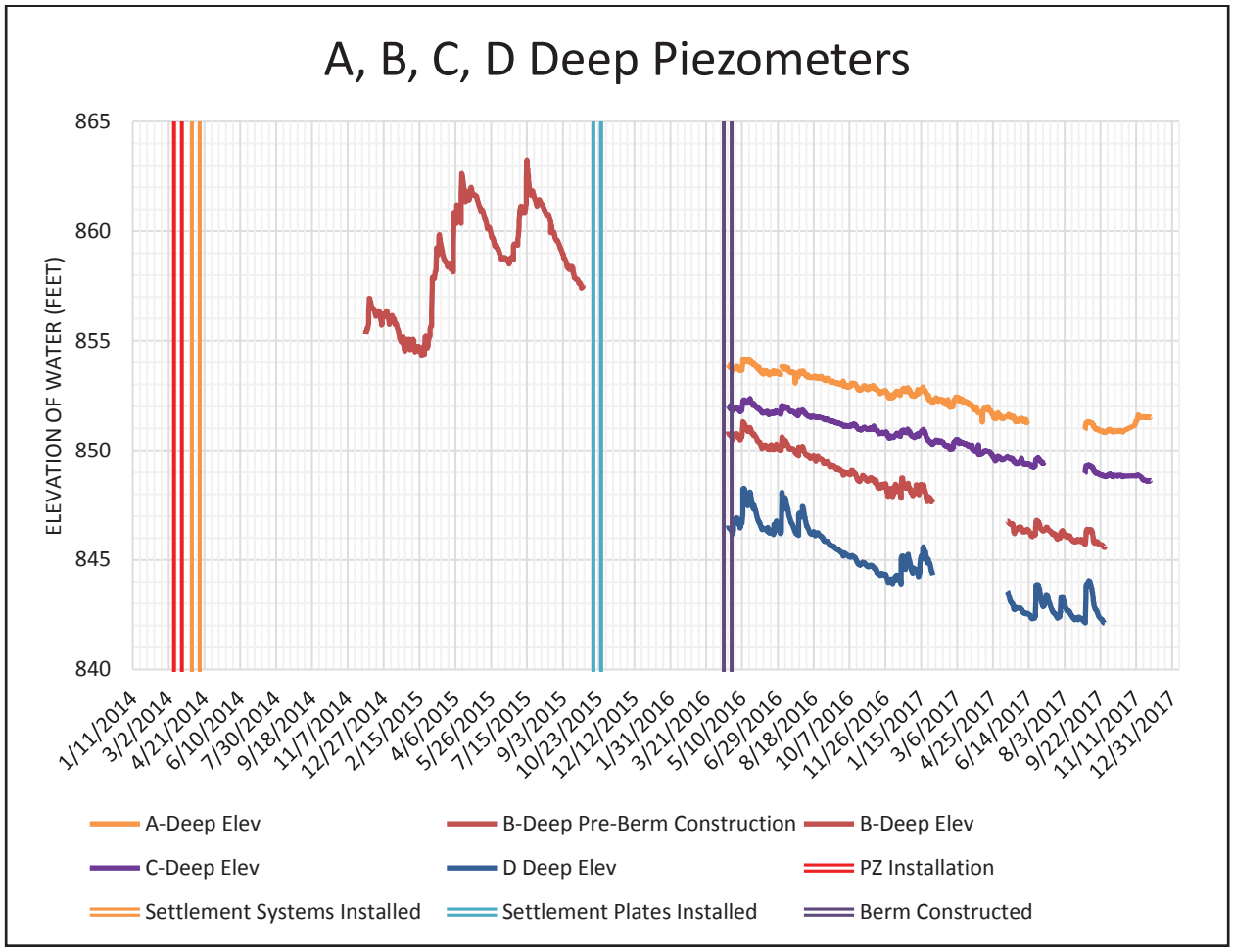
The settlement plate recorded a total settlement of approximately 4.2 inches in response to the 21 feet of gypsum placed on the test pad area. The deep piezometer recorded a short term maximum pressure head increase of 1.5 feet as settlement in the underlying saturated CCR increased the elevation of the water table as pore water was displaced by consolidation the voids in the CCR. The excess pore-water pressures appeared to dissipate relatively quickly (within a month) and were not observed to sustain peak pressures. Generally, a downward trend in the groundwater level was observed.

Phase 1 Monitoring Device Results

The measured field results for Phase 1 (“A”, ‘B”, “C”, and “D”) are shown in Graphs 2, 3, 4, and 5, below. Graphs 2 and 3 depict the piezometer results, presenting the elevation head with respect to time. Graphs 4 and 5 depict the settlement results, presenting the plate elevation with respect to time. For each graph, notable dates, such as the time of instrument installation, berm construction, instrument wire positioning movement, are represented by parallel vertical lines.



Graph 2 – Summary of Shallow Piezometer Measurements for Phase 1 Monitoring Instruments



Graph 3 – Summary of Deep Piezometer Measurements for Phase 1 Monitoring Instruments

Groundwater levels measured at locations “B” and “D”, at shallow depths, ranged from approximately 865 feet to approximately 872 feet; however, no groundwater was measured in “A” and “C”, at shallow depths. Furthermore, the groundwater levels (including dry conditions) at shallow depths remained relatively constant after the overlying landfill liner was placed in May of 2016.

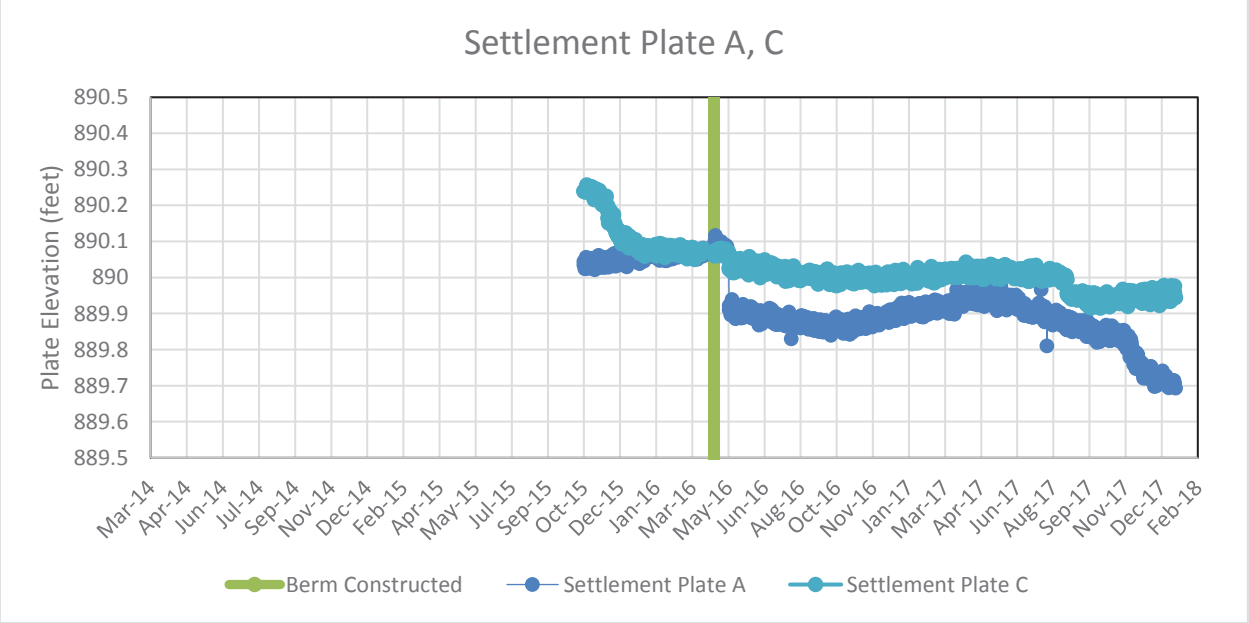
Groundwater levels measured in the deep piezometers (“A”, “B”, “C”, and “D”) range from approximately 842 feet to 854 feet. However, the piezometers indicated a downward trend over time.

In response to the divider berm construction and subsequent placement of approximately 4 feet of CCR in the area immediately over the monitoring locations, minor spikes in pore-water pressure were observed; however, the excess pore-water pressures appeared to dissipate relatively quickly (within a month) and were not observed to sustain peak pressures.

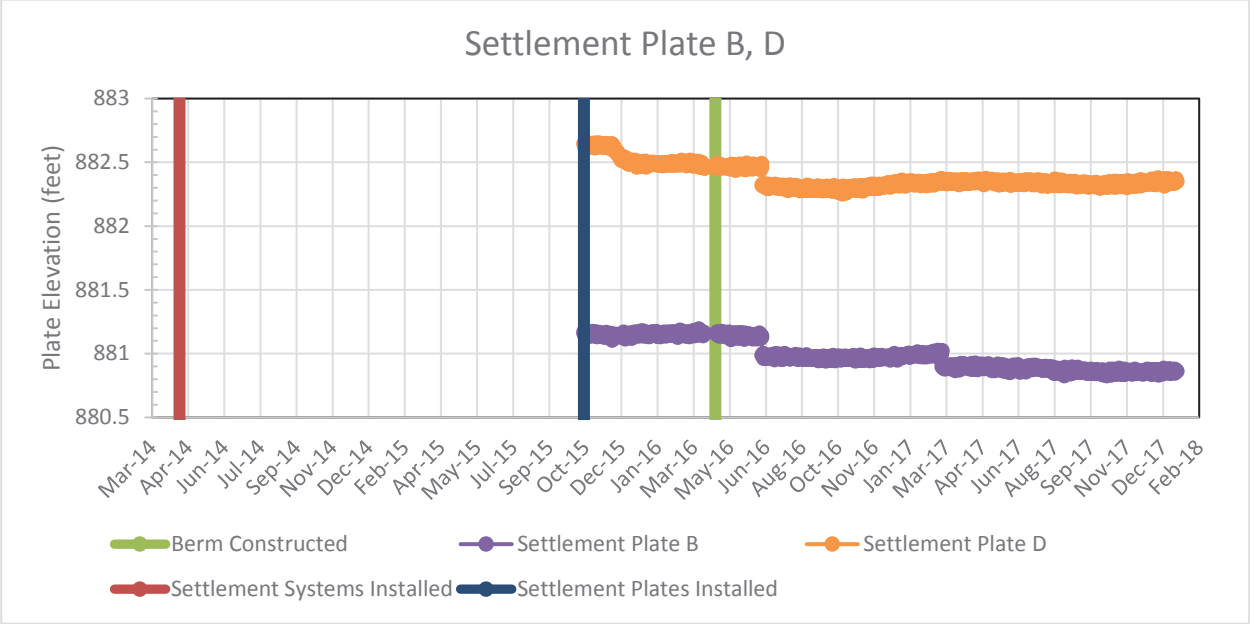
The piezometer monitoring device results for Phase 1 are summarized in Table 5, below:

Table 5 – Summary of Piezometer Results for Phase 1

Piezometer Name	Ground Elevation (feet)	Refusal Depth (feet, BGS)	Piezometer Depth (feet)	Piezometer Elevation (feet)	Highest Water Level Reading (feet)	Lowest Water Level Reading (feet)
Shallow Piezometers						
PZ-A	890.1	52.0	8	882.1	DRY	DRY
PZ-B	881.2	48.3	15	866.2	872.2	871.5
PZ-C	890.1	70.5	31.9	858.2	DRY	DRY
PZ-D	882.46	52.0	22.2	860.3	865.4	864.9
Deep Piezometers						
PZ-A	890.1	52.0	41.8	848.3	854.2	850.8
PZ-B	881.2	48.3	38	843.2	851.3	845.6
PZ-C	890.6	70.5	55.4	834.7	852.4	848.6
PZ-D	882.5	52.0	42.3	840.2	848.3	842.1



Graph 4 – Summary of "A' and "C" Settlement Plate Measurements for Phase 1



Graph 5 – Summary of "B' and "D" Settlement Plate Measurements for Phase 1

Settlement measurements from the settlement plates ranged from approximately 1 inch to 2.5 inches, in response to the divider berm construction and subsequent placement of 4 feet of new CCR.

The settlement monitoring device results for Phase 1 are summarized in Table 6, below:

Table 6 – Summary of Settlement Results for Phase 1

Settlement Plate Name	Ground Elevation (feet)	Depth to Rock (feet, BGS)	Settlement at Berm Completion (feet) (4/21/2016)	Settlement (feet) (10/21/2016)	Settlement (feet) (4/21/2017)	Settlement (feet) (10/21/2017)
A	890.1	52.0	0	0.2	0.2	0.2
B	881.2	48.3	0	0.0	0.1	0.1
C	890.1	70.5	0	0.1	0.1	0.2
D	882.5	52.0	0	0.2	0.1	0.2

Engineering Analysis

Our evaluation consisted of the following analysis cases:

1. Test pad analysis – A finite element (FE) model was created, which replicated the conditions of the test pad. The field monitoring device results were used to calibrate the hydraulic parameters of the existing CCR and determine the appropriate analysis type for the pore-water pressure evaluation and stability analyses described below.

2. Pore-water Pressure Evaluation – A FE model representing an embankment of new CCR in the location of Analysis Section AA', was evaluated to assess the development of excess pore-water pressure within the existing CCR deposits below the landfill. This analysis case represents a "worst case", in which the new CCR was placed in 10-foot vertical increments, every 60 days, reaching the height of the proposed landfill (40 feet). Plate 2, attached, illustrates the geometry of this embankment. The stability of the embankment section was evaluated for the increased pore-water pressure conditions.

3. Evaluation of Analysis Section AA' – Analysis Section AA' was created based on the modified landfill geometry (fully constructed) and evaluated for slope stability.

Analysis Case 1 - Test Pad Analysis

A subsurface model was created using Sigma/W software based on the subsurface conditions observed from the CPT soundings performed during test pad installation. The subsurface stratigraphy used to construct the model is summarized in Table 7. The bedrock surface was assumed to be horizontal.

Table 7 – Summary of Initial Model Conditions

Stratum	Depth (feet bgs)	Elevation (feet, NGVD)	Stratum Thickness (feet bgs)
Existing CCR	Surface	882.8	26.6
Residual Clay	26.6	856.2	7
Limestone Bedrock	33.6	849.2	--
Initial Groundwater Table	21.6	861.2	--

Twenty-one feet of gypsum fill was placed between the dates of 5-11-14 to 1-15-15. The gypsum fill loading sequence was replicated in the analysis model using three construction stages. Table 8 summarizes the loading sequence used in the analysis models.

Table 8 – Gypsum Fill Loading Sequence Summary

Construction Stage	Gypsum Fill Height (feet)	Fill Height Elevation (feet, NGVD)	Date		Time Interval (Days)	Accumulated Time (Days)
			Start	Finish		
1	5	887.8	5-11-14	7-7-14	61	61
2	11	893.8	7-7-14	8-21-14	45	106
3	21	903.8	8-21-14	1-15-15	147	253

Previous field studies of fly ash settlement under load, either experience consolidation over long periods of time from expulsion of excess pore-water, or immediate settlement from a linear-elastic response to the load. To determine which analysis type interprets the field monitoring results of the test pad, both a one-dimensional consolidation model and a linear-elastic model was developed.

Soil material properties used for the analysis models were obtained from field explorations and field testing performed at this site. Material properties available from industry-accepted references were used to supplement data as required. Table 9 provides a description of the model parameters used for our analysis and Table 10 summarizes the material properties input into the models.

Table 9 – Model Property Description Summary

Property	Property Description
Total Unit Weight (γ_{moist})	Weight density, weight of soil per unit volume[1]
Over Consolidation Ratio (OCR)	Ratio by which the current mean effective stress in the soil was exceeded[3]
Poisson's Ratio (ν)	Ratio of lateral and axial strains[3]
Young's Modulus of Elasticity (E)	ratio of applied stresses and strains[4]
Lambda (λ)	Slope of the normal consolidation line[3]
Kappa (κ)	Slope of the over-consolidation line[3]
Initial Void Ratio (e_o)	Ratio of volume of voids to volume of solids prior to loading[3]
Effective Friction Angle (ϕ')	Angle between the normal and resultant force, under drained conditions[2]
M	Slope of the critical state line (based on ϕ')[3]

Note: 1. Units are pounds per cubic feet (pcf)
2. Units are degrees
3. Unit-less
4. Units are kips per square feet (ksf)

Table 10 – Model Property Input Summary for the Existing CCR

Model Type	Material Property	Material Property Value	Reference
Consolidation (MCC)[a]	γ_{moist}	100 pcf	1
	OCR	1	1
	ν	0.334	3
	λ	0.122	1
	κ	0.024	(1, 2)[b]
	e_o	1.14	1
	ϕ'	25°	3
	M	0.984	(3, 2)[a]
Linear-Elastic	γ	100 pcf	1
	E	140,000 ksf	3
	ν	0.334	3

Note: a. Modified Cam Clay – A critical state model relating soil shear strength to consolidation parameters.
b. (Reference of value, Reference of equation)

An initial saturated vertical hydraulic conductivity (K_v) on the order of 1E-07 centimeters per second (cm/s) was applied to the existing CCR, which for flyash is considered a conservative value representing the lower bound hydraulic conductivity for a material with silt sized particles (Freeze and Cherry, 1979). A hydraulic conductivity ratio, representing the ratio of horizontal to vertical conductivity (K_v/ K_x) was used to provide anisotropic flow within the existing CCR in the model.

The procedures described below were used to predict the excess pore-water pressures and settlements measured in the existing CCR deposits below the test pad:

1. Initial model – An initial model was constructed to define the in-situ conditions. The geometry was created, material properties input, initial water table defined, mesh discretized, and stress-strain boundary constraints applied. The initial model was used as a starting stress state for both the MCC and the linear-elastic models.

2. Consolidation and Linear Elastic Analysis – A hydraulic head boundary condition was applied to the existing CCR deposits as the gypsum loading sequence was applied to the in-situ model, using the time of the actual fill schedule records. In the model, the gypsum fill load was applied in time increments in accordance with the following time steps:

Table 11 – Loading Time Step Summary

Lift Thickness (feet)	Elapsed Time (Days)
5	61
11	45
21	147

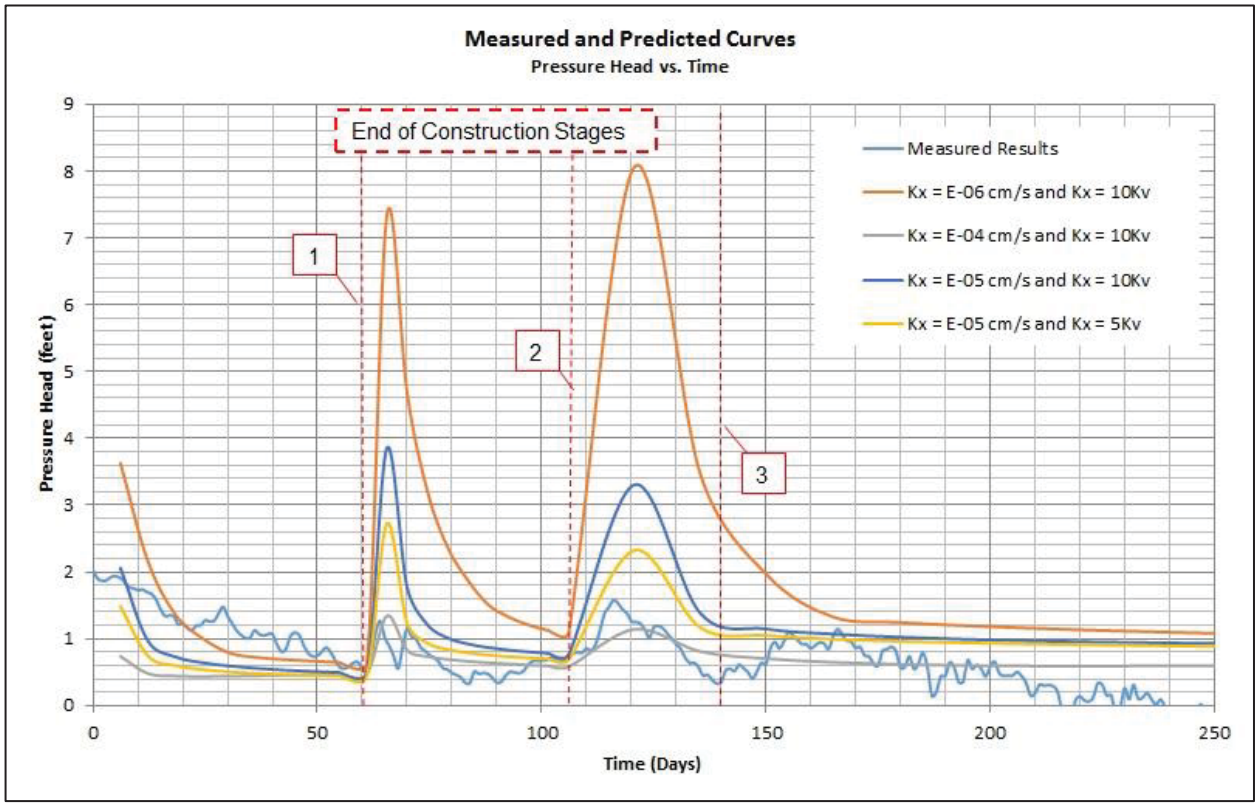
The model "places" fill on a user selected time increment and the remaining time is allotted for the pore-water to dissipate. This process was applied until the elapsed time for each lift

thickness was reached. After the elapsed time for all the lifts are reached, a 30-day dissipation period was selected for the settlements to reach equilibrium. The purpose of the time step application was to analyze the pore-water response and settlement over time.

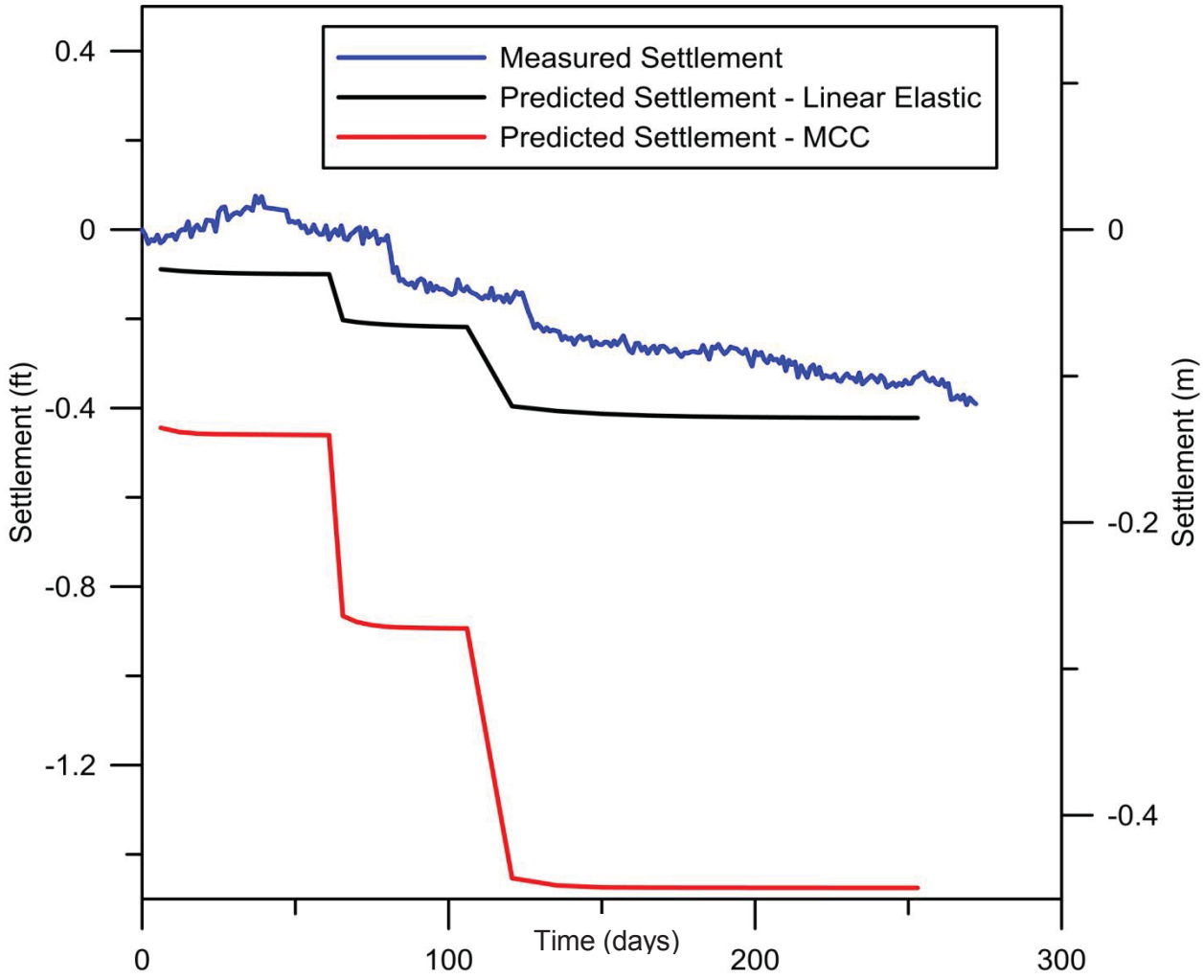
3. Sensitivity Analysis – The saturated K_x and K_v/K_x were adjusted systematically until the predicted total head response replicated the total head response measured within the test pad. Trial saturated K_x values ranged from 1E-06 cm/s to 1E-04 cm/s, with K_x/K_v values ranging from 5 to 10.

Analysis Case 1 - Test Pad Analysis Results

The results of the analysis models are shown in the graphs shown in Graphs 6 and 7, below. The graphs include both actual and predicted settlement and pore-water pressure measurements of the existing CCR in response to the gypsum fill loading, with respect to time.



Graph 6 – Measured and Predicted Pore-water Pressure Results



Graph 7 – Measured and Predicted Settlement Results

The following results were observed regarding measured and predicted pore-water pressure and settlement results from the loaded fly ash deposits within the test pad:

- The best fit pore-water pressure responses were obtained using a saturated K_x on the order of 1E-05 cm/s with a K_x/K_v ratio of 5, when compared to the measured pore-water pressure values.
- Less than 2-feet of pressure head was measured in the piezometer.
- The predicted settlement using the consolidation (MCC) analysis model over-estimated settlement, indicating approximately 18 inches of settlement.
- The predicted settlement using the Linear-elastic analysis model more accurately estimated settlement, indicating approximately 6 inches of settlement.

Analysis Case 2 – Pore-water Pressure Evaluation

A pore-water pressure evaluation was performed on the embankment shown on Plate 2, attached. The pore-water pressure evaluation was performed in two parts:

1. Performing a stress assessment to determine the peak pore-water pressure response to new CCR fill.
2. Evaluating the stability of the embankment at the peak pore-water pressure.

Stress Assessment

The stress assessment was performed by creating a FE model on the section shown on Plate 1 of this PM attachment. The assessment included predicting excess pore-water pressure, within the existing CCR deposits resulting from 40 feet of new CCR fill placed over the course of approximately 8 months (10 feet increment applied every 60 days). Based on the results of the test pad evaluation (Analysis Case 1), the stress assessment model incorporated a fully coupled, load-deformation analysis using a linear-elastic analysis. We consider this application time period to represent a very conservative or quick load application, not likely to be replicated in the field.

The geometry of the modeled section includes an embankment comprised of 40-feet of new CCR, placed across a 370-feet, long section of existing CCR, constructed with 3 horizontal to 1 vertical (3:1) side slopes. The model geometry and subsurface stratigraphy was modeled based on subsurface exploration findings gathered from field investigations performed by Amec Foster Wheeler and others, and the expected peak elevation of the future Station landfill cover.

The fill loading sequence was modeled using 4-10-foot-thick increments of CCR, each placed within a day and allowed to recover for a period of 2 months before application of the next increment. The program utilizes time periods to calculate excess pore-water pressure and pore-water dissipation, in response to the fill succession placement.

Soil material properties used for the pore-water pressure analysis models were the same properties used in our study of the test pad, which were obtained from field explorations and field testing performed at this site and industry-accepted references. The field monitoring devices installed in Phase 1 of the landfill indicated the highest measured perched water table within the CCR at an elevation of 872 feet; however, a water table elevation of 880 feet was used in the model as a conservative measure.

Based on the sensitivity analysis evaluated in our test pad model (Analysis Case 1), a K_v value of 10E-06 cm/sec for the existing CCR was selected, which is a mid-range to lower bound value representing a material with silt sized particles (Freeze and Cherry, 1979). A (K_x/ K_v) equal to 5 was applied to provide anisotropic flow within the model for the existing CCR.

We note that a less conservative value of 1.1E-02 cm/s was measured from field tests conducted by third party consultants. Additionally, we have performed hydraulic conductivity testing on remolded CCR samples, compacted to 95 percent of their maximum dry density. The results of our laboratory falling head tests provided in Volume 1 of our Landfill Application Permit, indicated a saturated K_v ranging from 1E-05 cm/s to 1E-06 cm/s.

The procedures described below were used to analyze the models to predict the excess pore-water pressures measured in the existing CCR deposits at the site.

1. An initial model was constructed to define the in-situ conditions as a starting stress state prior to new CCR fill placement. The geometry was created, the material properties were input, the initial water table was defined, the FE mesh was discretized, and stress-strain boundary constraints were applied.

2. A hydraulic head boundary condition was applied to the existing CCR deposits as the new CCR fill loading sequence was applied to the in-situ model, using the assumed time sequence of 2 months for each succession. Considering approximately 3 feet of fill was placed over a period of 17 months, 10 feet of fill placed in 2 months, would be considered a conservative fill sequence, i.e., the load is applied more rapidly in the model than is expected during actual construction.

3. The excess pore-water pressure was calculated in response to each 10-feet succession, over the course of 8 months.

4. Global Stability of the embankment model was evaluated at the peak pore-water pressure (discussed next).

Embankment Global Stability Analysis

Amec Foster Wheeler developed a modeling approach to assess the global stability of the embankment shown on Plate 2, at the peak pore-water pressure (4^{th} 10-foot load increment). Slope stability analysis was conducted using the GeoStudio software suite Slope/w developed by GEO-SLOPE International, Ltd. The program uses a two-dimensional finite element, stress-based, limit equilibrium method of analysis and calculates the factor of safety based on the stress distribution caused by the new CCR fill placement. A static and pseudo-static case was performed for the time increment identified as having the highest pore-water pressure.

Global stability analysis requires Mohr-Coulomb (based on c and φ) parameters to compute base normal and shear stress within potential slip surfaces. The Mohr-Coulomb parameters used for the analysis were based on parameters presented in Table 5.3.1 of Attachment 28 "*Bottom Liner Risk Analysis*", of our Permit Application. The following table is a summary of the soil properties used in the analyses.

Table 12 – Assumed Soil Strength Parameters

Condition	New CCR Fill	Existing CCR	Bedrock
Effective Stress Condition	γ = 100 pcf c = 100 psf φ = 32°	γ = 95 pcf c = 0 psf φ = 28°	Impenetrable

A PGA of 0.083 g, corresponding to the local earthquake scenario was used in our pseudo-static analysis. The seismic conditions evaluated for the Station Landfill were explained in section 5.4 of Attachment 28 "*Bottom Liner Risk Analysis*", of our Permit Application.

Using the stress distribution resulting from the new CCR fill placement determined from the load-deformation analysis, the critical stress state was analyzed for slope stability. The procedures described below were used to analyze the model to predict the factors of safety for slope stability.

1. The Potential slip surfaces are formed using a series of grids and radii. The Potential slip surfaces are discretized into slices and the stresses are defined at the midpoint of the elements for each slice.

2. The inclination angle, normal and shear stress at the base of each slice are computed.

3. The available shear strengths are computed from the normal stress.

4. The mobilized shear and available strength are multiplied by the length of each slice base to convert the stress to force.

5. The factor of safety is calculated as the ratio of total available shear resistance to the total mobilized shear along the entire length of the potential slip surfaces.

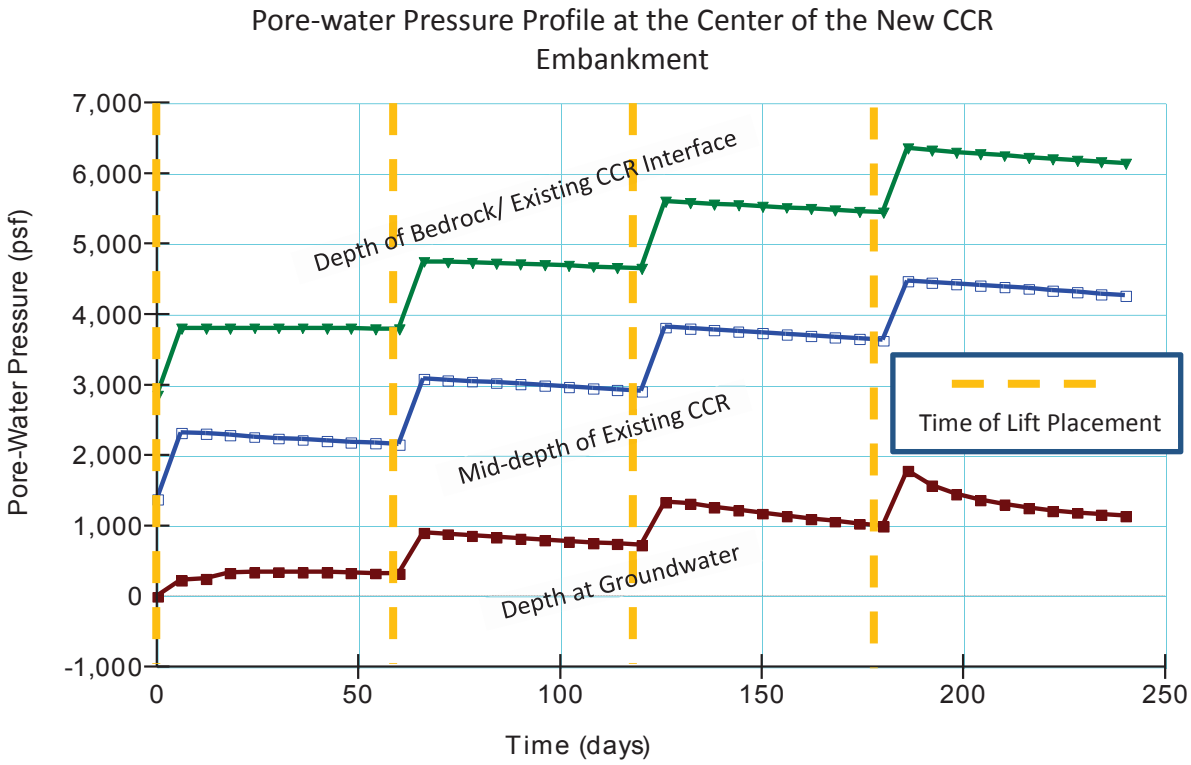
6. This process was completed for peak pore-water pressure evaluated in the stress assessment.

7. A Pseudo-static analysis case was performed, by applying an inertial force equivalent to the Peak Ground Acceleration (PGA) applied in a horizontal direction to the centroid of each slice.

Analysis Case 2 - Pore-water Pressure Evaluation Results

The results of the stress assessment are shown on Graph 8, and the results of the embankment global stability analysis is shown in Table 13 below. The graph describes the predicted excess pore-water pressure developed in the existing CCR (at the center of the embankment mass) in response to the fill successions, at each fill succession time (every 2 months), where excess pore-

water pressure is defined as the amount of pressure increased beyond hydrostatic pressure. Table 13 presents the factor of safety values for each lift placed.



Graph 8 –Predicted Pore-water Pressure Results

Table 13 – Factor of Safety Values for Each Fill Succession

Cumulative Lift Succession Height	Cumulative Time Increment	Target Factor of Safety		Static Factor of Safety Value	Pseudo Static Factor of Safety Value
		Static	Pseudo Static		
10	60	1.5	1.0	2.32	1.88
20	120			2.23	1.86
30	180			1.86	1.51
40	240			1.64	1.30

The following results were observed regarding the predicted excess pore-water pressure results from the loaded existing CCR deposits:

- In response to 40 feet of new CCR placement, over the course of 8 months, the pore-water pressure (Below the center of the 40-foot-thick embankment) increases from 0 psf, to approximately 2,000 psf at the initial water table depth, which corresponds to a pressure

head of approximately 30 feet; however, the porewater dissipates to a pressure of approximately 1,000 psf, which corresponds to a pressure head of approximately 15 feet.

- The peak excess pore-water pressure occurs at 186 days, shortly after the 4th succession of new CCR fill was placed.

- Factor of safety values are above target values.

Analysis Case 3 – Section AA' Global Stability Re-evaluation

Amec Foster Wheeler developed a modeling approach to re-evaluate the global stability of Analysis Section AA', (location shown on Plate 1) based on the changes in cap geometry. From a geotechnical standpoint, notable geometry modifications that would effect slope stability include height and side slope. The geometry modifications, based on the new landfill design are shown in Table 14, below.

Table 14 – Summary of New Landfill Design Height and Side Slope Modifications

Geometry Item	Previous Design	New Design	Change
Maximum Height (feet)	90	40	50 ft decrease
Side Slope (%)	3	5	2% flatter slopes

Slope stability analysis was conducted using the GeoStudio software suite Slope/w developed by GEO-SLOPE International, Ltd. The program uses a two-dimensional finite element, stress-based, limit equilibrium method of analysis and calculates the factor of safety based on the stress distribution caused by the new CCR fill placement. A static and pseudo-static case was performed for the analysis section at landfill completion.

Global stability analysis requires Mohr-Coulomb (based on c and φ) parameters to compute base normal and shear stress within potential slip surfaces. The Mohr-Coulomb parameters used for the analysis were based on parameters presented in Table 5.3.1 of Attachment 28 "*Bottom Liner Risk Analysis*", of our Permit Application. The following table is a summary of the soil properties used in the analyses.

Table 15 – Assumed Soil Strength Parameters

Condition	New CCR Fill	Existing CCR	Bedrock
Effective Stress Condition	γ = 100 pcf c = 100 psf φ = 32°	γ = 95 pcf c = 0 psf φ = 28°	Impenetrable

A groundwater table elevation of 880 feet was used in our stability analysis. A PGA of 0.083 g, corresponding to the local earthquake scenario was used in our pseudo-static analysis. The seismic conditions evaluated for the Station Landfill were explained in section 5.4 of Attachment 28 "*Bottom Liner Risk Analysis*", of our Permit Application.

The procedures described below were used to analyze the model to predict the factors of safety for slope stability.

1. The Potential slip surfaces are formed using a series of grids and radii. The Potential slip surfaces are discretized into slices and the stresses are defined at the midpoint of the elements for each slice.

2. The inclination angle, normal and shear stress at the base of each slice are computed.

3. The available shear strengths are computed from the normal stress.

4. The mobilized shear and available strength are multiplied by the length of each slice base to convert the stress to force.

5. The factor of safety is calculated as the ratio of total available shear resistance to the total mobilized shear along the entire length of the potential slip surfaces.

6. A Pseudo-static analysis case was performed, by applying an inertial force equivalent to the Peak Ground Acceleration (PGA) applied in a horizontal direction to the centroid of each slice.

Analysis Case 3 - Global Stability Section AA' Re-evaluation Results

The results of the global stability Section AA' Re-evaluation are shown in Table 16 below. Table 16 presents the factor of safety values for deep slip surfaces, penetrating through the existing ash, below the north side slope. The analysis results are shown on Plate 3, attached.

Table 16 – Factor of Safety Values for Each Fill Succession

Target Factor of Safety		Static Factor of Safety Value	Pseudo Static Factor of Safety Value
Static	Pseudo Static		
1.5	1.0	8.66	4.08

Conclusion

A monitoring system consisting of 4 settlement plates and 4 nested piezometers were installed in Phase 1 of the landfill. Construction of the starter berm and placement of approximately 3-10 feet of new CCR materials within Phase 1 was monitored for responses in pore-water pressure and settlement.

Amec Foster Wheeler evaluated a test pad, instrumented with a settlement plate and a series of nested piezometers, located in Phase 3 area of the landfill. Approximately 21 feet of gypsum fill was placed over the monitoring system, and a FE model of the test pad was created to predict the existing CCR response of the gypsum load. The FE model was calibrated using the results from the test pad instrumentation to determine the appropriate analysis type, CCR shear strength and hydraulic properties. The model was used to assess if placement of CCR with a surface differential greater than 10 feet would be stable, by analyzing an embankment constructed of rapidly placed, new CCR, constructed 40-feet high, with 3:1 side-slopes.

Analysis section AA' (also used in our Landfill Permit Application) extending in the north-south direction, was re-evaluated based on the new geometry. Slope stability analysis was performed for long-term (Static) and short-term (Pseudo-Static) conditions for the fully constructed landfill.

Monitoring Device Conclusions

The monitoring system installed under Phase 1 Cell 1, indicates the following:

- The groundwater identified in shallow piezometers "A" and "D" was interpreted as a perched water zone, ranging in elevation from approximately 865 feet to 872 feet.
- Shallow piezometers "B" and "C", were interpreted to be dry.
- Pore-water pressure did not develop within the shallow piezometers, in response to construction of the starter berm and 3 to 5 feet of new CCR placement.
- The groundwater identified in the deep piezometers ranged from approximately 842 feet to 854 feet.
- The downward trend observed in the deep piezometer measurements indicates the groundwater table is freely draining.

Pore-water Pressure Evaluation

Based on the results of the pore-water pressure evaluation, Amec Foster Wheeler has made the following conclusions:

- The calibrated model of the test pad, based on the data collected from monitoring system "J", indicated a linear elastic analysis best models pore-pressure and settlement response.

- The best fit pore-water pressure responses obtained from the sensitivity analysis, resulting in a saturated K_v on the order of 1E-06 cm/s with a K_x/K_v ratio of 5, is considered a conservative value.

- The pore-water pressure evaluation was considered conservative because of the rapid loading sequence of the new CCR (40 feet in 8 months) the applied high groundwater table (880 feet), and low vertical hydraulic conductivity (1E-06 cm/s).

- The settlement plates were observed to continually settle beyond the construction of the starter berm and placement of new CCR.

- The apparent continuing settlement may be a result of an increase in effective stress due to the load transferred to the existing CCR material-matrix by the ongoing draining of the groundwater table.

- The high horizontal permeability and lenticular nature of sluiced CCR deposits, coupled with a freely-draining and deep groundwater table, allow for very rapid dissipation of pore pressures induced by surcharge loading.

Global Stability Section AA' Re-evaluation

Based on the results of the Global Stability Section AA' Re-evaluation, Amec Foster Wheeler has made the following conclusions:

- From a geotechnical standpoint, the design changes in landfill geometry would increase the global stability of the proposed landfill.

- The results of our re-evaluation based on the Station Landfill design changes, indicate acceptable short-term and long-term factors of safety for the duration of landfilled CCR placement.

Closing Remarks

The data collected from our monitoring devices, the results from our pore-water pressure evaluation, and the results from our stability analysis, demonstrate excess pore-water pressure does not develop to a critical level, new CCR in the landfill placed with a surface differential of greater than10 feet, and the proposed landfill configuration are stable. Placement of new CCR materials as the landfill is constructed, will be continually monitored and our FE models will be calibrated accordingly.

References

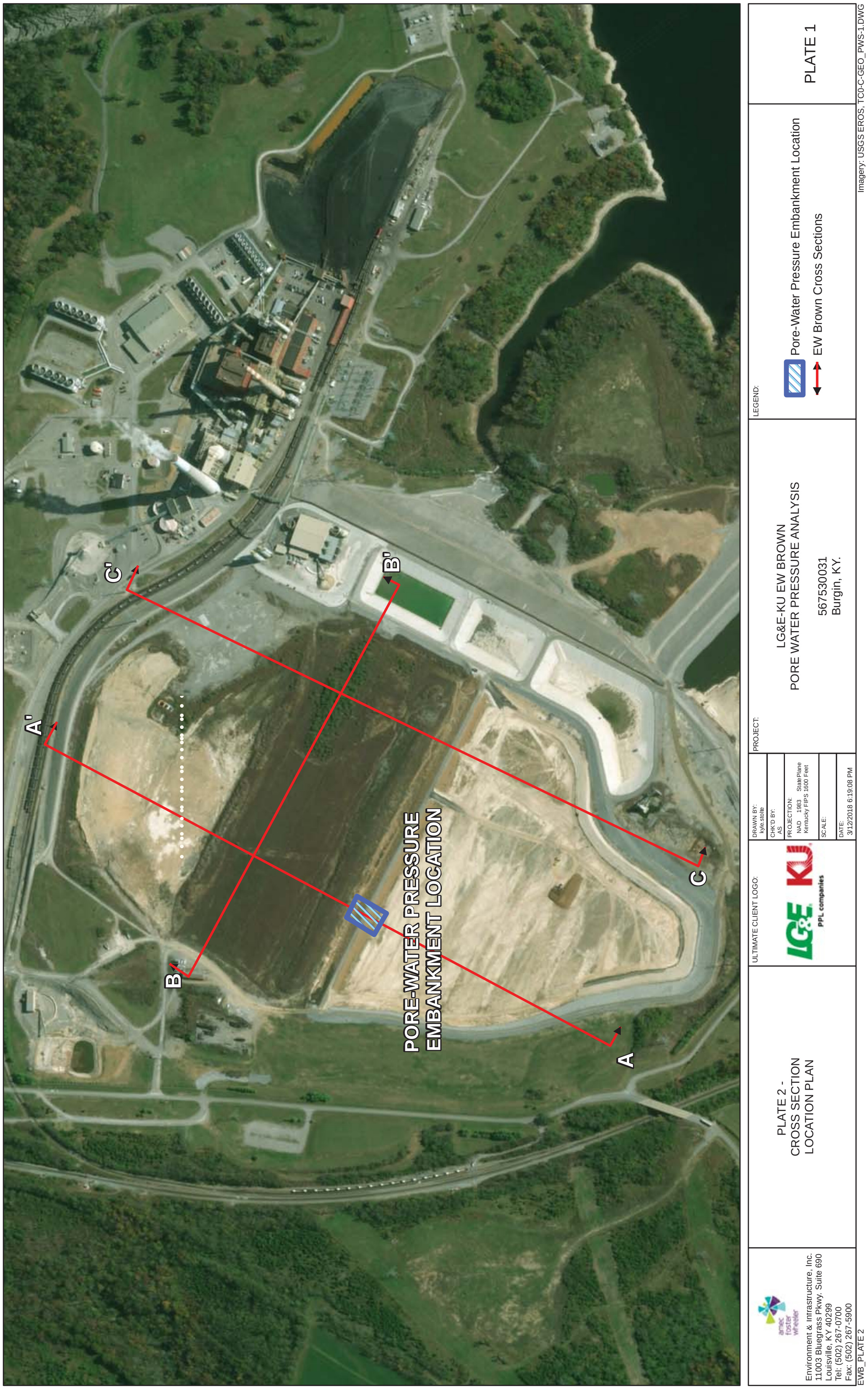
[1] Fuller, Mossbarger, Scott & May (FMSM), Geotechnical Characterization of Ash Basin Deposits [Preliminary and Confidential Report], 2006, 9.

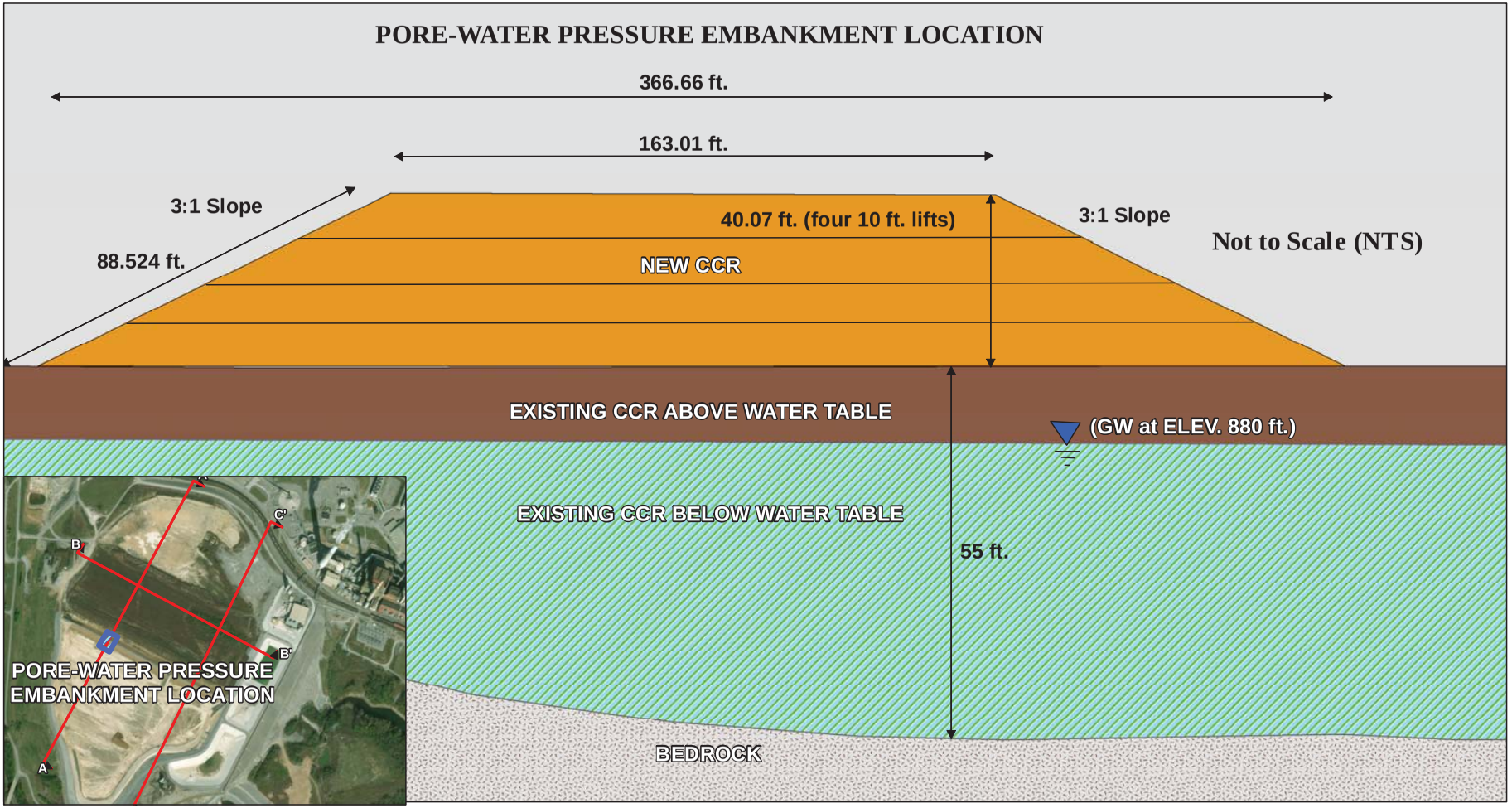
[2] Muni Budhu, Soil Mechanics and Foundations, John Wiley & Sons, Inc., New York, 2000.

[3] Joseph E. Bowles, Foundation Analysis and Design, Fourth Edition, McGraw-Hill, Inc., New York, 1988.

[4] Table 1, Typical Properties of Compacted Soils, NAVAC DM – 7.2, May 1982.

[5] R. Allan Freeze and John A. Cherry, Groundwater, Prentice Hall, Inc., New York, 1979.


PORE-WATER PRESSURE
EMBANKMENT LOCATION
A
A'
B
B'
C
C'
PLATE 1
LEGEND:
Pore-Water Pressure Embankment Location
EW Brown Cross Sections
PROJECT:
LG&E-KU EW BROWN
PORE WATER PRESSURE ANALYSIS
567530031
Burgin, KY.
DRAWN BY: kyle.stolle
CHK'D BY: AS
PROJECTION: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
SCALE:
DATE: 3/12/2018 6:19:08 PM
ULTIMATE CLIENT LOGO:
PPL companies
PLATE 2 -
CROSS SECTION
LOCATION PLAN
amec foster wheeler
Environment & Infrastructure, Inc.
11003 Bluegrass Pkwy, Suite 690
Louisville, KY 40299
Tel: (502) 267-0700
Fax: (502) 267-5900
EWB_PLATE 2
Imagery: USGS EROS, TC0-C-GEO_PWS-1.DWG



amec foster wheeler
Environment & Infrastructure, Inc.
11003 Bluegrass Pkwy. Suite 690
Louisville, KY 40299
Tel: (502) 267-0700
Fax: (502) 267-5900

PLATE 1 -
PORE-WATER PRESSURE
EVALUATION - NEW CCR EMBANKMENT

ULTIMATE CLIENT LOGO:
LG&E KU
PPL companies

DRAWN BY: kyle.stolte
CHK'D BY: AS
PROJECTION: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
SCALE: 1:1,345 1 inch = 112 feet
DATE: 3/12/2018 6:31:46 PM

PROJECT:
LG&E-KU EW BROWN
PORE-WATER PRESSURE ANALYSIS

567530031
Burgin, KY.

LEGEND:
- Pore-Water Pressure Embankment
- Bedrock
- Existing CCR Above Water Table
- Existing CCR Below Water Table
- New CCR

PLATE 2

EWB_Slopexx

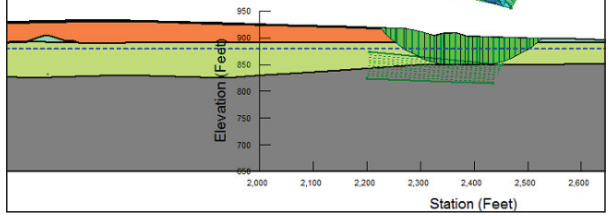
Imagery: USGS EROS, TC0-C-GEO_PWS-1.DWG

Analysis Section AA' Global Stability Re-evaluation Results

Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Existing CCR	Mohr-Coulomb	1	95	0	28	0
	Existing Embankment Material	Mohr-Coulomb	1	125	250	25	0
	New CCR Fill	Mohr-Coulomb	1	100	0	32	0

F of S: 3.415

Pseudo-Static Slope Stability - Deep Failure



Color	Name	Model	Piezometric Line	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)	1				
	Existing CCR	Mohr-Coulomb	1	95	0	28	0
	Existing Embankment Material	Mohr-Coulomb	1	125	250	25	0
	New CCR Fill	Mohr-Coulomb	1	100	0	32	0

F of S: 7.165

Static Slope Stability - Deep Failure

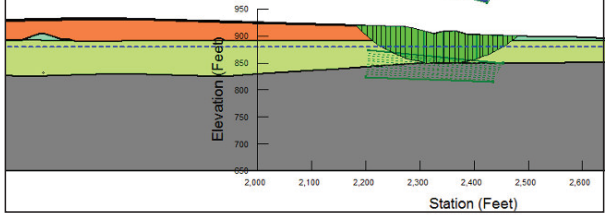


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PLATE 1 -
PORE-WATER PRESSURE
EVALUATION - NEW CCR EMBANKMENT

ULTIMATE CLIENT LOGO:

LG&E KU
PPL companies

DRAWN BY: kyle.stolte
CHK'D BY: AS
PROJECTION: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
SCALE: 1:1,345 1 inch = 112 feet
DATE: 3/12/2018 6:31:46 PM

PROJECT:

LG&E-KU EW BROWN
PORE-WATER PRESSURE ANALYSIS

567530031
Burgin, KY.

LEGEND:

PLATE 3

EWB_Slopexx

Imagery: USGS EROS, TC0-C-GEO_PWS-1.DWG

PM Attachment 7 - Photos of Bonded Area Construction

Figure 7-1 - Closure Plan and Liner Details

Figure 7-2 - Photo Location Plan

Photo log (Photos A-I)

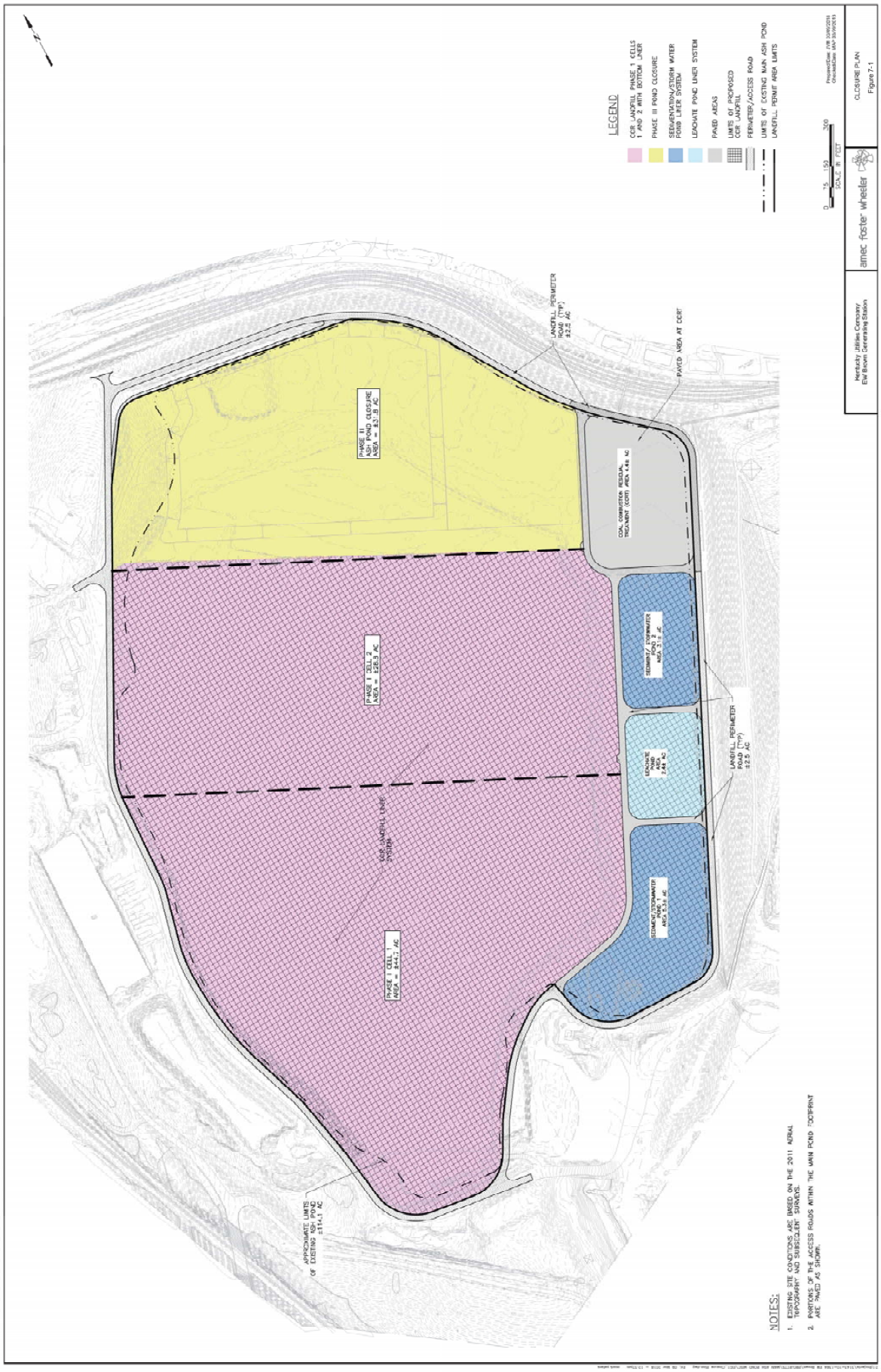
LEGEND
CCR LANDFILL PHASE 1 CELLS 1 AND 2 WITH BOTTOM LINER
PHASE III POND CLOSURE
SEDIMENTATION/STORM WATER POND LINER SYSTEM
LEACHATE POND LINER SYSTEM
PAVED AREAS
LIMITS OF PROPOSED CCR LANDFILL
PERIMETER/ACCESS ROAD
LIMITS OF EXISTING MAIN ASH POND
LANDFILL PERMIT AREA LIMITS
0 75 150 300
SCALE IN FEET
Kentucky Utilities Company
Ebi Brown Generating Station
amec foster wheeler
CLOSURE PLAN
Figure 7-1
PHASE III ASH POND CLOSURE AREA = ±53.8 AC
PHASE I CELL 2 AREA = ±26.3 AC
PHASE I CELL 1 AREA = ±44.7 AC
CCR LANDFILL LINER SYSTEM
APPROXIMATE LIMITS OF EXISTING MAIN ASH POND = ±114 AC
LANDFILL PERIMETER ROAD (TYP) ±2.5 AC
COAL COMBUSTION RESIDUAL (CCR) AREA 4.6± AC
PAVED AREA AT CCR
SEDIMENT/STORMWATER POND 1 AREA 5.3 AC
LEACHATE POND AREA 2.4± AC
SEDIMENT/STORMWATER POND 2 AREA 3.1± AC
NOTES:
1. EXISTING SITE CONDITIONS ARE BASED ON THE 2011 AERIAL TOPOGRAPHY AND SURVEYED SURVEYS.
2. PORTIONS OF THE ACCESS ROADS WITHIN THE MAIN POND FOOTPRINT ARE PAVED AS SHOWN.

Photo	Direction	Description
A	SW	Road along Coal Combustion Residual Treatment Material Handling Area
A'	NE	Road along Coal Combustion Residual Treatment Material Handling Area
B	S	Road along Coal Combustion Residual Treatment Material Handling Area
B'	N	Road along Coal Combustion Residual Treatment Material Handling Area
C	SW	Road along Sediment/Stormwater Pond 2
C'	NE	Road along Sediment/Stormwater Pond 2
D	SE	Road between CCR TMHA and Sediment/Stormwater Pond 2
D'	NW	Road between CCR TMHA and Sediment/Stormwater Pond 2
E	SE	Road between Sediment/Stormwater Pond 2 and Leachate Pond Area
E'	NW	Road between Sediment/Stormwater Pond 2 and Leachate Pond Area
F	SW	Road along Leachate Pond Area
F'	NE	Road along Leachate Pond Area
G	SE	Road between Sediment/Stormwater Pond 1 and Leachate Pond Area
G'	NW	Road between Sediment/Stormwater Pond 1 and Leachate Pond Area
H	SW	Road along Sediment/Stormwater Pond 1
H'	NE	Road along Sediment/Stormwater Pond 1
I	SW	Road along Sediment/Stormwater Pond 1
I'	NE	Road along Sediment/Stormwater Pond 1

	CLIENT: LG&E KU PPL companies	MAP BY: KPS	TITLE: PHOTO LOCATION PLAN	PROJECT NO: 567530031 DATE: 3-9-2017
Amec Foster Wheeler 690 Commonwealth Center 11003 Bluegrass Parkway Louisville, KY 40299	amec foster wheeler	DATUM: NAD83 PROJECTION: UTM Zone 16N SCALE: As Shown	PROJECT: EW BROWN PHASE II LANDFILL MOD	ATTACHMENT 7 FIGURE NO: 7-2

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

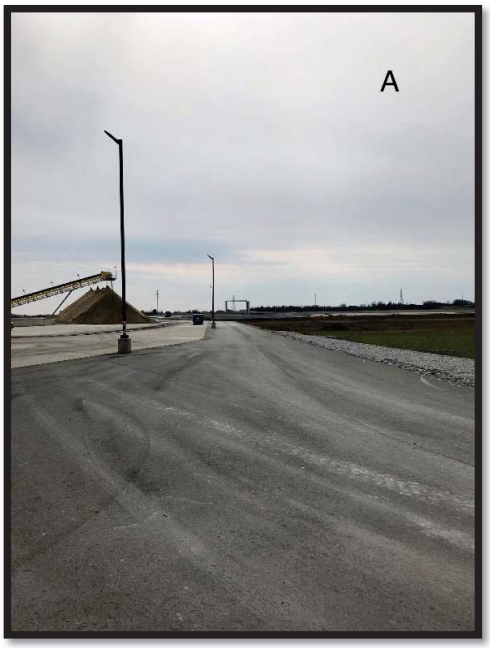

Photo A: Road along Coal Combustion Residual Treatment Material Handling Area

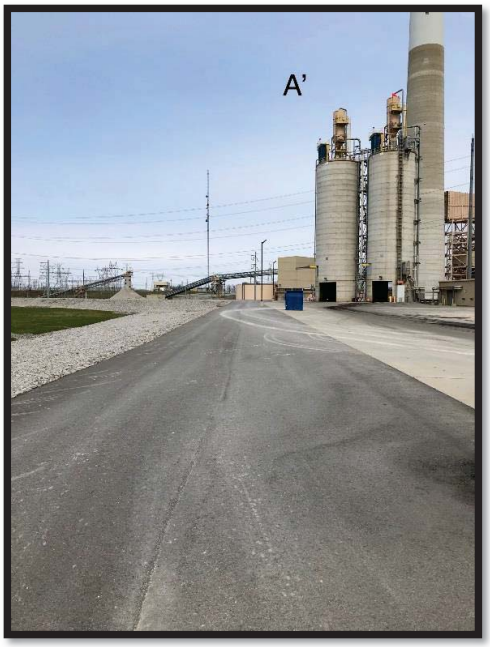

Photo A': Road along Coal Combustion Residual Treatment Material Handling Area

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

Photo B: Road along Coal Combustion Residual Treatment Material Handling Area

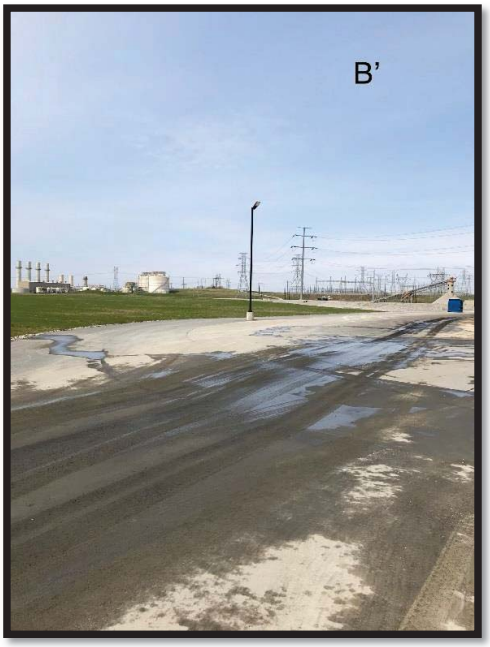

Photo B': Road along Coal Combustion Residual Treatment Material Handling Area

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

Photo C: Road along Sediment/Stormwater Pond 2

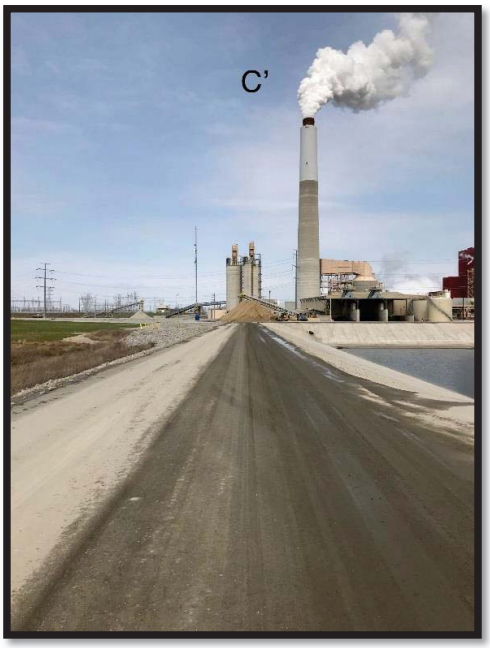

Photo C': Road along Sediment/Stormwater Pond 2

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

Photo D: Road between CCR TMHA and Sediment/Stormwater Pond 2

Photo D': Road between CCR TMHA and Sediment/Stormwater Pond 2

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

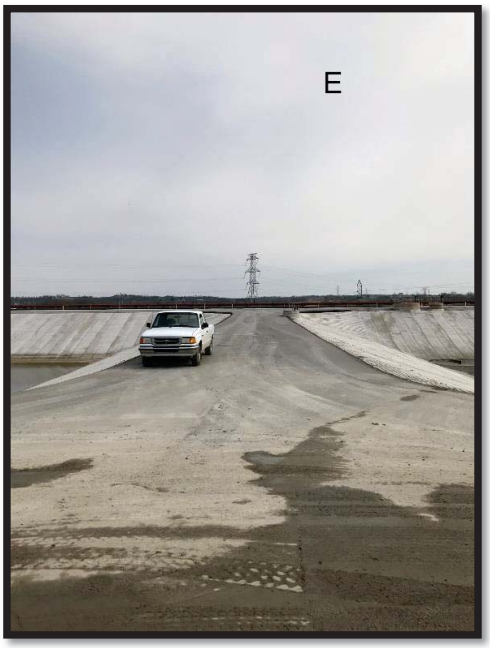

Photo E: Road between Sediment/Stormwater Pond 2 and Leachate Pond Area

Photo E': Road between Sediment/Stormwater Pond 2 and Leachate Pond Area

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

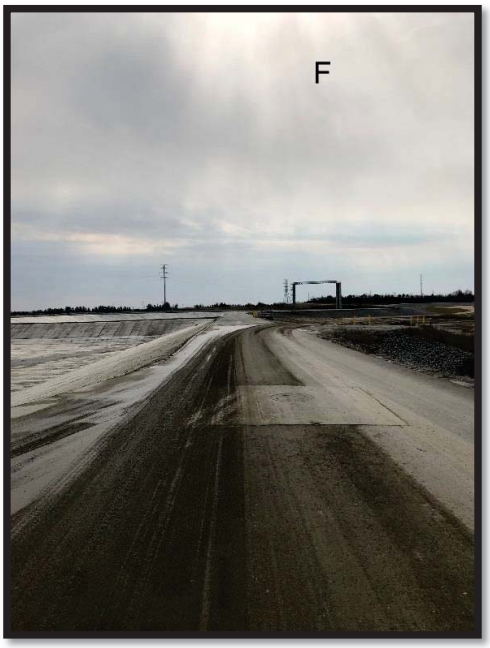

Photo F: Road along Leachate Pond Area

Photo F': Road along Leachate Pond Area

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

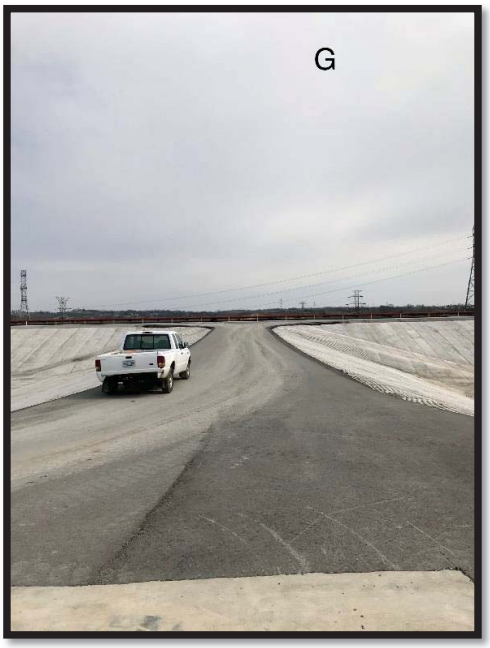

Photo G: Road between Sediment/Stormwater Pond 1 and Leachate Pond Area

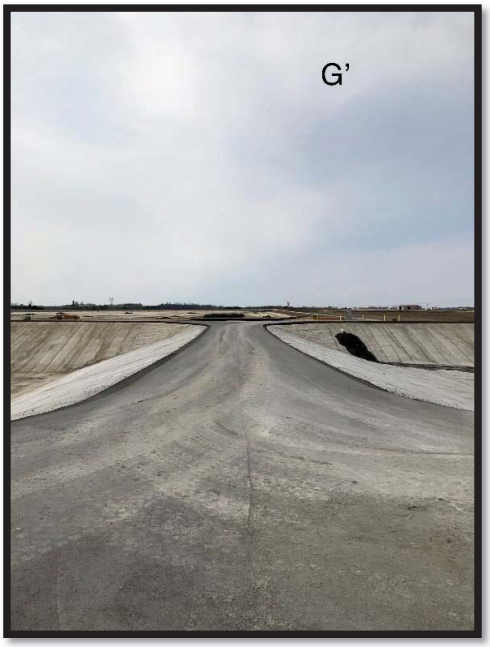

Photo G': Road between Sediment/Stormwater Pond 1 and Leachate Pond Area

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

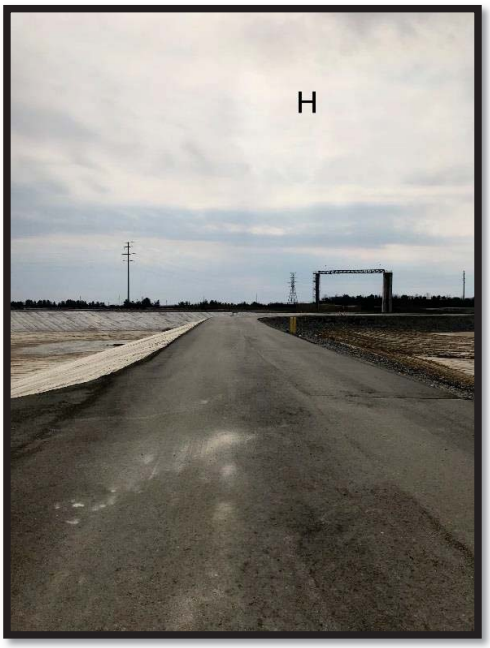

Photo H: Road along Sediment/Stormwater Pond 1

Photo H': Road along Sediment/Stormwater Pond 1

LG&E-KU EW Brown Generating Station

Closure Plan Site Walk Photographs, March 9, 2018

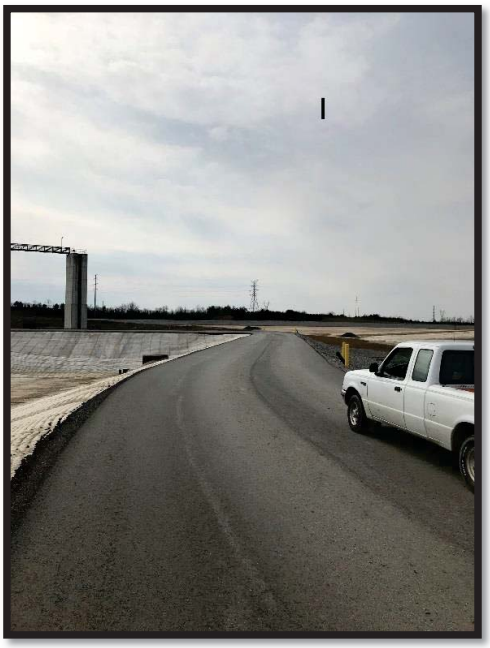

Photo I: Road along Sediment/Stormwater Pond 1

Photo I': Road along Sediment/Stormwater Pond 1

PM Attachment 8 - Cover Specifications

Section 31 05 19.13 Geotextiles

Section 31 05 19.16 Geomembranes

Section 31 05 19.19 Geogrids

Section 31 05 19.23 Geosynthetic Clay Liners

Section 31 05 19.26 Geocomposites

SECTION 31 05 19.13

GEOTEXTILES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Agreement and Division 01 Technical Specifications, apply to this Technical Specification.

B. Kentucky Transportation Cabinet (KYTC) "Standard Specifications", 2012.

1.2 SUMMARY

A. This Technical Specification covers furnishing all labor and equipment for installation of Contractor-supplied Geotextile Type I and Type II fabric material for the Project.

B. Use Type I geotextile fabric in locations shown on the drawings as follows:

1. CCR Impoundment Closure.
    a. Final cover system underdrain.
    b. Cover system perimeter drain.
2. Landfill Modifications.
    a. Cover system perimeter drain.
    b. Storm water system manholes.

C. Use Type II geotextile fabric in locations shown on the drawings as follows:

1. CCR Impoundment Closure.
    a. Armored final cover system.
    b. Aggregate road buildup.
    c. Cover system access ramps.
    d. Southwest storm water sump.
2. Process Pond Construction.
    a. Liner system.

b. Rock slope protection.

c. Aggregate road buildup.

d. Concrete access ramp.

3. Landfill Modifications.

a. Bottom liner system.

b. Leachate management system headers and collection interceptors.

c. Vegetated and armored final cover system.

d. Cover system access ramps.

e. Rock slope protection.

f. Aggregate road buildup.

g. Paved road buildup.

h. Pavement repairs.

4. West Collection Basin Demolition.

a. Final cover.

D. Perform or cause the performance of all laboratory quality control (QC) testing and field/laboratory quality assurance (QA) testing as specified herein.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Technical Specification 01 11 00 – Summary of Work

B. Technical Specification 01 33 00 - Submittal Procedures

C. Technical Specification 31 05 19.16 – Geomembranes

D. Technical Specification 31 05 19.26 – Geocomposites

E. Technical Specification 31 20 00 – Earth Moving

F. Technical Specification 31 25 00 – Erosion and Sedimentation Control

G. Technical Specification 31 37 00 – Riprap

H. Technical Specification 32 11 23 – Aggregate Base Courses

I. Technical Specification 33 05 33.16 – High Density Polyethylene (HDPE) Pipe

1.4 REFERENCES

A. The publications listed below, latest edition unless otherwise noted, form a part of this Technical Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM)

1. ASTM D3786/D3786M-13	Standard Test Method for Bursting Strength of Textile Fabrics – Diaphragm Bursting Strength Tester Method
2. ASTM D4354-12	Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
3. ASTM D4355/D4355M-14	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus
4. ASTM D4491/D4491M-16	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
5. ASTM D4533/D4533M-15	Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
6. ASTM D4632/D4632M-15a	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
7. ASTM D4751-16	Standard Test Methods for Determining Apparent Opening Size of a Geotextile
8. ASTM D4759-11	Standard Practice for Determining the Specification Conformance of Geotextiles
9. ASTM D4833/D4833M-07(2013)e1	Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
10. ASTM D4873/D4873M-16	Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
11. ASTM D4884/D4884M-14a	Standard Test Method for Strength of Sewn or Bonded Seams of Geotextiles
12. ASTM D5199-12	Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
13. ASTM D5261-10	Standard Test Method for Measuring Mass per Unit Area of Geotextiles

C. Kentucky Transportation Cabinet (KYTC):

1. KYTC Standard Specifications – “Standard Specifications”, 2012.

1.5 DEFINITIONS AND RESPONSIBILITIES

A. Contractor: The Contractor is the firm or corporation with whom Owner has entered the Agreement to perform the Work on the Project. The Contractor is responsible for the following as required by this Technical Specification:

1. Purchasing and furnishing the geotextile materials including appurtenances required for this Project.

2. Review of submittals by the Manufacturer and the Contractor's Installer.

3. Scheduling and coordination of the required Work with the Manufacturer and the Contractor's Installer to complete the Project.

4. Oversees the installation of the geotextile by the Contractor's Installer.

5. Inspections and reviewing testing results for compliance with the specified requirements.

6. Compiles the QA test results daily and documents the QA activities in weekly reports.

B. Manufacturer: The Manufacturer is the firm or corporation contracted by the Contractor for production of the geotextile material to be used in the Project. The Manufacturer produces a consistent product meeting or exceeding the specifications and provides QC documentation for the product(s) specified herein.

C. Contractor's Installer: The Contractor's Installer is the firm or corporation contracted by the Contractor for installation of the geotextile. The Contractor's Installer can be the Manufacturer or a Manufacturer-approved installer trained and certified to install the Manufacturer's geotextile. The Contractor's Installer is responsible for field handling, storing, placing, seaming, sampling, testing, protecting and other aspects of the geotextile installation.

D. Quality Control Laboratory: An independent Quality Control Laboratory (QCL) hired by the Contractor to perform compliance testing of the geotextile material with demonstrated qualifications for conducting required testing.

E. Construction Quality Assurance (CQA): CQA inspections are conducted by an independent third party specializing in geomembrane quality assurance/quality control (QA/QC). The CQA monitor collects samples and conducts independent QA testing.

1.6 QUALIFICATIONS

A. Manufacturer: Demonstrate the Manufacturer's ability to produce this geotextile by having at least five (5) years continuous experience in the manufacturing of geotextile and successfully manufactured a minimum of ten (10) million square feet of similar material for geotextile installations.

B. Contractor's Installer: The Contractor's Installer can be the Manufacturer or a Manufacturer-approved installer trained to install the Manufacturer's geotextile. Perform installation under the constant direction of a single installation supervisor who remains on the Job Site and is in responsible charge, through the geotextile installation, seaming, patching, testing, repairs and other Job Site activities required by the Contractor's Installer.

1.7 SUBMITTALS

A. General: Submit each item in this Technical Specification in accordance with the Conditions of the Agreement and Technical Specification 01 33 00 - Submittal Procedures.

B. Submittals relating to the geotextile Manufacturer and the geotextile material:

1. Manufacturing:

a. List of material properties of the geotextile proposed for the Project meeting the requirements specified herein with attached certified test results.

b. Manufacturer's QC program and manual including description of in-house laboratory facilities.

c. A list of ten (10) completed projects totaling a minimum of ten (10) million square feet, for which the Manufacturer has manufactured the geotextile specified to be used on this Project. Provide the following information for each project:

(1) Name and purpose of project, the project location, and date of installation.

(2) Name of the owner, project manager, design engineer, and installer.

(3) Geotextile type and surface area.

d. Qualifications statement in accordance with Paragraph 1.5 of this Technical Specification.

e. Manufacturer's recommendations for geotextile installation procedures.

C. Submittals relating to the Contractor's installer:

1. Installation Capabilities:

a. Information on equipment and personnel.

b. Anticipated average daily production.

c. Number of crews employed and number available for this Work.

d. Qualifications statement in accordance with Paragraph 1.5 of this Technical Specification.

2. A list of five (5) completed projects totaling two (2) million square feet for which the Contractor's Installer has installed the geotextile specified to be used on this Project. Provide the following information for each project:

a. Name and purpose of the project, the project location, and date of installation.

b. Name of the owner, design engineer, Manufacturer, and name and telephone number of Manufacturer's representative at the facility who can discuss the project.

c. Surface area of the installed geotextile.

d. Type of seaming, patching and tacking equipment.

e. A copy of the Manufacturer's certification or approval letter.

D. Within thirty (30) Business Days prior to geotextile installation, submit the following:

1. Installation QC:

a. A QC manual that specifically defines the QC program during installation for this Project. Include daily procedures, seaming techniques, specific steps that are to be taken in the event of a failure or defect, personnel requirements, levels of authority and other information necessary to ensure a high-quality geotextile installation consistent with the Manufacturer recommendations and this Technical Specification in the manual.

b. Resume of the installation supervisor to be assigned to and on the Job Site during the Project.

c. A list of personnel performing installation and seaming operations along with pertinent experience information.

1.8 QUALITY CONTROL

A. In addition to Manufacturer and Contractor's Installer requirements for qualifications and certification specified in Paragraph 1.6 of this Technical Specification, QC consists of compliance testing of the material prior to delivery to the Job Site and field QC during installation.

B. Manufacturer compliance testing requirements are specified in Paragraph 2.2 of this Technical Specification. The purpose of compliance testing is to verify that the supplied material complies to the requirements of this Technical Specification and to the Manufacturer's QC certificates.

C. Geotextile QC Documentation:

1. Project Files:

a. Maintain two (2) duplicate Project files. One Project file is maintained by the Contractor and the other Project file is maintained by the Contractor's Installer. The Contractor's Installer provides the Contractor with complete daily documentation by the end of the following Business Day. At the end of each Work week, the Contractor and Contractor's Installer update and check the Project files to assure that copies of pertinent Project information are included in each file.

b. Make blank copies of the Project forms available on the Job Site throughout the duration of the Project.

1.8 DELIVERY, STORAGE AND HANDLING

A. Package and ship the geotextile rolls by appropriate means to prevent damage of the geotextile rolls. Off-loading, handling, and storage of the geotextile is the responsibility of the Contractor's Installer. The Contractor's Installer is responsible for replacing any damaged or unacceptable geotextile material.

B. Roll Identification: The manufacturer provides geotextile rolls marked or tagged with the following information:

1. Manufacturer's name.

2. Product identification.

3. Thickness.

4. Roll dimensions.

5. Manufacturer's roll and lot number.

6. Date of manufacture.

C. Damage during off-loading is documented by the Contractor. Damaged geotextile rolls must be separated from the undamaged geotextile rolls and removed by the Manufacturer from the Job Site.

D. Store the geotextile rolls to be protected from puncture, dirt, grease, water, mud, mechanical abrasions and excessive heat or cold that may damage the geotextile material. Store the geotextile rolls on a prepared surface (not wooden pallets or hard abrasive surfaces) and do not be stacked more than two (2) rolls high.

PART 2 PRODUCTS

2.1 MATERIAL

A. Type I Geotextile Fabric

1. Furnish Type I geotextile fabric, a non-woven polyester or polypropylene fabric (refer to the KYTC "Standard Specifications, 2012 – Section 843). The minimum physical requirements for the Type I geotextile fabric are presented in the attached Table 1.

B. Type II Geotextile Fabric

1. Furnish Type II geotextile fabric, a non-woven polyester or polypropylene fabric (refer to the KYTC "Standard Specifications, 2012 – Section 843). The minimum physical requirements for the Type II geotextile fabric are presented in the attached Table 2.

2.2 MANUFACTURING QUALITY CONTROL

A. Manufacture the geotextile in accordance with the Manufacturer's QCP submitted to and approved by the Owner.

B. Geotextile material in non-compliance with this Technical Specification is subject to rejection.

2.3 COMPLIANCE TESTING

A. Tests: Perform compliance testing by an independent QCL provided and paid for by the Contractor. Obtain the samples from the roll, mark the machine direction and identification number and ship the samples to the QCL by the Manufacturer. If appropriate arrangements are made with the Manufacturer, the QCL can go to the Manufacturer's facility and obtain the required samples. Performed the compliance tests for the geotextile material properties listed in the attached Table 1 for Type I Geotextile Fabric or Table 2 for Type II Geotextile Fabric.

B. Frequency: Perform the compliance tests in accordance with Table 1 and Table 2 at a frequency of one sample per 100,000 square feet unless otherwise noted or approved by the Contractor.

C. Acceptance or Rejection: Prior to shipment of the geotextile to the Job Site, the Contractor reviews the compliance test results for acceptance or rejection of the geotextile materials. Test results must meet, or exceed, the property values listed in Table 1 for Type I Geotextile Fabric or Table 2 for Type II Geotextile Fabric for acceptance of the geotextile fabrics. The course of action implemented for retesting failing tests is approved by the Owner. In case of failing test results, the Manufacturer can request that another sample be retested by the independent laboratory with the Manufacturer's technical representative present during the testing procedures. The Manufacturer can also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results, the material is accepted. If both laboratories do not report passing results, the geotextile material from the lot or

bracketed square footage representing the failing sample is considered out of specification and rejected for use on this Project.

PART 3 EXECUTION

3.1 SHIPMENT AND STORAGE

A. During all periods of shipment and storage, protect the geotextile fabric from direct sunlight, ultraviolet rays, temperature greater than 140° F, mud, dirt, dust and debris. To the extent possible, maintain the geotextile fabric wrapped in a heavy duty protective covering until installed.

3.2 EARTHWORK

A. Surface Preparation:

1. Do not place geotextiles onto an area which has been softened by precipitation and/or condensation or which has cracked due to desiccation. Observe the soil surface daily to evaluate the effects of desiccation cracking and/or softening of the integrity of the soil surface.

2. Repair any damage to the soil surface caused by installation activities.

3.3 INSTALLATION

A. Prior to implementing any of the Work described in this Technical Specification, become thoroughly familiar with all portions of the Work described within this Technical Specification and related Technical Specifications.

B. Inspection:

1. Prior to implementing any of the Work in this Technical Specification, carefully inspect the installed Work of all other Technical Specifications and verify that all Work is complete to the point where the Work of this Technical Specification may properly commence without adverse impact.

2. If the Contractor has any concerns regarding the installed Work of other Technical Specifications, notify the Owner in writing prior to the start of the Work of this Technical Specification. Failure to inform the Owner in writing is construed as the Contractor's acceptance of the related Work of all other Technical Specifications.

C. General:

1. Adhere to the Manufacturer's recommendations and this Technical Specification during installation of the Type I and Type II geotextile fabric.

2. Handle the geotextiles in such a manner as to ensure the geotextiles are not damaged in any way.

3. Take precautions to prevent damage to underlying layers during placement of the geotextile.

4. After removing the opaque cover from the geotextile, do not leave the geotextiles exposed for a period greater than 30 Days unless a longer exposure period is approved by the Owner, based on a formal demonstration from the Contractor that the geotextile is stabilized against UV degradation for a period greater than of 30 Days.

    a. Remove all labels from the geotextile roll and/or packaging and submit to the Owner by the Contractor's Installer.

5. Take precautions against "snow blindness" of personnel, if white-colored geotextile is used.

6. Take care during placement of the geotextile to not entrap stones, excessive dust, or moisture in the geotextile during placement.

7. In the presence of wind, weigh down the geotextiles with sand bags or the equivalent. Installed the sand bags during placement and the sand bags remain until replaced with overlying layers of material above the completed geotextile fabric installation.

8. Examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Remove foreign objects and replace damaged geotextile.

D. Seams and Overlaps

1. Install the geotextiles with non-sewn, minimum overlap of thirty-six (36) inch seams for geotextile fabric placed on slopes less than 4H:1V.

2. Use a single seam line sewn formed as a super imposed (or prayer) seam or a folded super imposed (or "J) seam with a minimum tail of six (6) inches beyond the seam for geotextile fabric placed on 4H:1V and greater.

3. The Manufacturer's recommendations for overlap requirements apply, if the Manufacturer's recommendations for overlap requirements are more stringent.

4. To the greatest extent practicable, orient the geotextile sheets parallel to the line of maximum slope, i.e., oriented down, not across, the slope.

5. Overlap the geotextiles such that the downgradient geotextile sheet is placed under the upgradient geotextile sheet creating the overlap.

6. Use hot wedge or hot air seaming (lystering) with approval by the Owner of written procedures, equipment, and seamer's experience provided by the Contractor's Installer.

E. Sewing

1. On slopes 4H:1V and steeper, join adjacent strips of geotextile fabric by stitching together continuously.

2. All stitches are Class 401 with a minimum of five (5) stitches per inch. The stitched line is a minimum of two inches from the fold, if a "J" seam is used.

3. Use the same material as the geotextile fabric for thread used in sewing.

4. All seam strengths equal to or greater than 90 percent of the grab tensile strength of the geotextile fabric as determined by ASTM D4632/D4632M-15a.

F. Repair

1. Repair any holes or tears in the geotextile as follows:

   a. Spot seam in place a patch made from the same geotextile with a minimum of two (2) feet overlap in all directions.

   b. Should any tear exceed ten (10) percent of the width of the sheet, remove and replace the sheet with new material.

2. Take care to remove any soil or other material which may have penetrated the torn geotextile.

G. Protection from Damage

1. Protect the geotextile fabric during installation from impacts by surface runoff. Work such that the covering of the geotextile fabric with a layer of the specified material is accomplished within seven (7) Days after placement of the geotextile fabric.

H. Removal and Replacement

1. Any damage during installation, placement of materials or failure to cover geotextile fabric within the specified time, warrants removal and replacement of the geotextile fabric by the Contractor.

I. Metal Detectors

1. For needle punched geotextile fabric, also certify, by the Manufacturer, the geotextile fabric has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic or geomembrane layers. The certificate of compliance is attested to by a person having legal authority to bind the geotextile fabric Manufacturer.

3.4 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus geotextile fabric and waste materials, including trash, and debris, and legally dispose of off the Owner's property.

END OF SECTION

Table 1. Minimum Physical Properties of Type I Geotextile Fabric

Property	Units	Test Method	Value	Frequency
Unit Weight	oz/yd^2	ASTM D5261-10	8	1/100,000 SF
Grab Tensile Strength	lbs	ASTM D4632/D4632M-15a	220	1/100,000 SF
Grab Tensile Elongation	%	ASTM D4632/D4632M-15a	50	1/100,000 SF
CBR Puncture Strength	lbs	ASTM D6241-14	575	1/100,000 SF
Water Flow Rate	gpm/sf	ASTM D4491/D4491M-16	95	1/100,000 SF
Apparent Opening Size	Sieve	ASTM D4751-16	80	1/100,000 SF
Trapezoidal Tear	lbs	ASTM D4533/D4533M-15	90	1/100,000 SF
Permittivity	sec^{-1}	ASTM D4491/D4491M-16	1.30	1/100,000 SF
UV Resistance	%	ASTM D4355/D4355M-14	70[a]	Per formulation

Notes:

a – Minimum at 500 hours of exposure.

lbs – pounds; gpm/sf – gallons per minute per square foot; oz/yd^2 – ounces per square yard; % - percent; SF – square feet; ASTM - American Society for Testing and Materials

The above tests are performed by the Manufacturer of the Type I Geotextile for identification of the Manufacturer's product. Submit the test results to the Contractor for approval of the product. The geotextile supplied for the Project meets these properties.

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Table 2. Minimum Physical Properties of Type II Geotextile Fabric

Property	Units	Test Method	Value	Frequency
Unit Weight	oz/yd^2	ASTM D5261-10	16	1/100,000 SF
Grab Tensile Strength	lbs	ASTM D4632/D4632M-15a	390	1/100,000 SF
Grab Tensile Elongation	%	ASTM D4632/D4632M-15a	50	1/100,000 SF
CBR Puncture Strength	lbs	ASTM D6241-14	1,125	1/100,000 SF
Water Flow Rate	gpm/sf	ASTM D4491/D4491M-16	45	1/100,000 SF
Permittivity	sec^{-1}	ASTM D4491/D4491M-16	0.6	1/100,000 SF
Apparent Opening Size	Sieve	ASTM D4751-16	100	1/100,000 SF
Trapezoidal Tear	lbs	ASTM D4533/D4533M-15	150	1/100,000 SF
UV Resistance	%	ASTM D4355/D4355M-14	70[a]	Per formulation

Notes:

a – Minimum at 500 hours of exposure.

psi – pounds per square inch; lbs – pounds; % - percent; gpm/sf – gallons per minute per square foot; sec – seconds; oz/yd^2 – ounces per square yard; ASTM - American Society for Testing and Materials

The above tests are performed by the Manufacturer of the Type II Geotextile for identification of the Manufacturer's product. Submit the test results to the Contractor for approval of the product. The geotextile supplied for the Project meets these properties.

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SECTION 31 05 19.16

GEOMEMBRANES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Agreement and Division 01 Technical Specifications, apply to this Technical Specification.

1.2 SUMMARY

A. This Technical Specification covers the technical requirements for the manufacturing, installation, and testing of the following:

1. 40-mil textured (both sides) Linear Low-Density Polyethylene (LLDPE) geomembrane positioned below the geocomposite drainage layer (GDL) and above the final cover system subbase functioning as the barrier layer for the final cover system of the CCR Impoundment Closure as shown on the Project drawings.

2. 60-mil textured (both sides) High Density Polyethylene (HDPE) geomembrane positioned below the cushion geotextile and above the geosynthetic clay liner (GCL) functioning as a component of the composite barrier layer for the Process Pond liner system as shown on the Project drawings.

3. 60-mil textured (both sides) Linear Low-Density Polyethylene (HDPE) geomembrane positioned below the geocomposite drainage layer (GDL) and above the geosynthetic clay liner (GCL) functioning as a component of the composite barrier layer for the Landfill Modification liner system as shown on the Project drawings.

4. 40-mil textured (both sides) Linear Low-Density Polyethylene (LLDPE) geomembrane positioned below the geocomposite drainage layer (GDL) and above the final cover system subbase functioning as the barrier layer for the final cover system of the Landfill Modification as shown on the Project drawings.

B. Furnish materials to meet or exceed the requirements of this Technical Specification. Perform the Work in accordance with the procedures provided in the Technical Specifications including furnishing labor, materials, equipment and incidentals required to install and test the 40-mil textured LLDPE geomembrane, the 60-mil textured LLDPE geomembrane, and the 60-mil textured HDPE geomembrane.

C. Perform or cause the performance of all laboratory quality control (QC) testing and field/laboratory quality assurance (QA) testing as specified herein.

D. Perform or cause the performance of a geomembrane leak location survey for the Landfill Modification bottom liner geomembrane using electrical methods for post-

geomembrane installation performance for the geomembrane covered with geocomposite and gypsum materials and underlain by GCL and earth materials.

E. Kentucky Division of Waste Management Participation: Notify the Owner at least five (5) Business Days for inspection of each stage of the CCR Impoundment final cover system construction, the Process Pond liner system construction and the Landfill Modification liner system construction and the final cover system construction. The Owner is required to notify the Kentucky Division of Waste Management (KDWM) for each stage of the final cover system and liner system construction to allow a KDWM representative to be present for inspections. Do not proceed with additional construction without approval by the Owner and KDWM.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Technical Specification 01 11 00 – Summary of Work

B. Technical Specification 01 33 00 - Submittal Procedures

C. Technical Specification 01 78 39 - Project Record Documents

D. Technical Specification 03 20 00 - Fabric-Form Concrete

E. Technical Specification 31 05 19.13 – Geotextiles

F. Technical Specification 31 05 19.23 – Geosynthetic Clay Liners

G. Technical Specification 31 05 19.26 – Geocomposites

H. Technical Specification 31 20 00 – Earth Moving

I. Technical Specification 33 05 33.16 – High Density Polyethylene (HDPE) Pipe

J. Technical Specification 33 05 73 – Polyethylene Manholes and Structures

1.4 REFERENCES

A. The publications listed below, latest edition unless otherwise noted, form a part of this Technical Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM)

1. ASTM D698-12e2	Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbs/ft^3 (600 kN-m/m^3)
2. ASTM D792-13	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

3. ASTM D1004-13	Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
4. ASTM D1238-13	Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
5. ASTM D1505-10	Standard Test Method for Density of Plastics by the Density-Gradient Technique
6. ASTM D1603-14	Standard Test Method for Carbon Black in Olefin Plastics
7. ASTM D3895-14	Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
8. ASTM D4218-15	Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
9. ASTM D4437/D4437M-16	Standard Practice for Non-Destructive Testing (NDT) Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes
10. ASTM D4833/D4833M-07(2013)e1	Standard Test Method for Index Puncture Resistance of Geotextile, Geomembranes and Related Products
11. ASTM D5321/D5321M-14	Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
12. ASTM D5323-92(2011)	Standard Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes
13. ASTM D5596-03(2016)	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
14. ASTM D5617-04(2015)	Standard Test Method for Multi-Axial Tension Test for Geosynthetics
15. ASTM D5721-08(2013)	Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
16. ASTM D5885/D5885M-15	Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry
17. ASTM D5994/D5994M-10(2015)e1	Standard Test Method for Measuring the Core Thickness of Textured Geomembrane
18. ASTM D6392-12	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using

	Thermo-Fusion Methods
19. ASTM D6693/D6693M-04(2015)e1	Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
20. ASTM D6747-15	Standard Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes
21. ASTM D7007-16	Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earthen Materials
22. ASTM D7466/D7466M-10(2015)e1	Standard Test Method for Measuring Asperity Height of Textured Geomembranes

C. Geosynthetic Research Institute (GRI) Standards

1. GRI GM6	Pressurized Air Channel Test for Dual Seamed Geomembranes
2. GRI GM11	Accelerated Weathering of Geomembranes using a Fluorescent UVA-Condensation Exposure Device
3. GRI GM12	Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage
4. GRI GM13	Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
5. GRI GM17	Test Methods, Test Properties and Testing Frequency for Linear Low-Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

D. Relevant publications from the Environmental Protection Agency (EPA): Daniel, D.E. and R.M. Koerner, (1993), Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

1.5 DEFINITIONS AND RESPONSIBILITIES

A. Contractor: The Contractor is the firm or corporation with whom Owner has entered the Agreement to perform the Work on the Project. The Contractor is responsible for the following as required by this Technical Specification:

1. Purchasing and furnishing the geomembrane materials including appurtenances required for this Project.

2. Review of submittals by the Manufacturer and the Contractor's Installer.

3. Scheduling and coordination of the required Work with the Manufacturer and the Contractor's Installer to complete the Project.

4. Oversees the installation of the geomembrane by the Contractor's Installer.

5. Inspections and reviewing testing results for compliance with the specified requirements.

6. Compiles the QA test results daily and documents the QA activities in weekly reports.

B. Manufacturer: The Manufacturer is the firm or corporation contracted by the Contractor for production of the geomembrane material to be used in the Project. The Manufacturer produces a consistent product meeting or exceeding the specifications and provides QC documentation for the product(s) specified herein.

C. Contractor's Installer: The Contractor's Installer is the firm or corporation contracted by the Contractor for installation of the geomembrane. The Contractor's Installer can be the Manufacturer or a Manufacturer-approved installer trained and certified to install the Manufacturer's geomembrane. The Contractor's Installer is responsible for field handling, storing, placing, seaming, sampling, testing, protecting and other aspects of the geomembrane installation.

D. Leak Location Subcontractor: The Leak Location Subcontractor is the firm or corporation contracted by the Contractor to perform leak testing of the geomembrane. The Leak Location Subcontractor is responsible for providing equipment and personnel for performing the leak testing of the installed geomembrane following installation of the protective soil cover component of the bottom liner/leachate collection system associated with the Landfill Modifications.

E. Quality Control Laboratory: An independent Quality Control Laboratory (QCL) hired by the Contractor to perform compliance testing of the geomembrane material with demonstrated qualifications for conducting the required testing.

F. Construction Quality Assurance (CQA): CQA inspections are conducted by an independent third party specializing in geomembrane quality assurance/quality control (QA/QC). The CQA monitor collects samples and conducts independent QA testing.

G. Lot - A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geomembrane rolls. The finished rolls are identified by a roll number traceable to the resin lot.

1.6 QUALIFICATIONS

A. Manufacturer: Demonstrate the Manufacturer's ability to produce this geomembrane by having at least five (5) years continuous experience in the manufacturing of LLDPE and

HDPE geomembrane and successfully manufactured a minimum of ten (10) million square feet of similar material for hydraulic barrier installations.

B. Contractor's Installer: The Contractor's Installer can be the Manufacturer or a manufacturer-approved installer trained to install the Manufacturer's geomembrane. Perform installation under the constant direction of a single installation supervisor who remains on the Job Site and is in responsible charge through the subgrade approval, geomembrane installation/layout, seaming, patching, testing, repairs and other Job Site activities required by the Contractor's Installer.

1. The Contractor's Installer also provides a master seamer (who may also be the installation supervisor).

2. The installation supervisor/master seamer has worked in a similar capacity on at least three (3) projects similar in size and complexity to the Project described in the Agreement.

3. The installation supervisor/master seamer has installed or supervised the installation and seaming of a minimum of two (2) million square feet of LLDPE and HDPE geomembrane.

C. Leak Location Subcontractor: The leak location subcontractor possesses qualifications and experience in conducting the leak location survey method including having tested a minimum of 10,000,000 square feet of geomembrane liner within the previous three (3) years. In addition, the leak location surveys are supervised by a professional or technician with a minimum of three (3) years and 5,000,000 square feet of geomembrane testing experience using the leak location survey method. The leak location supervisor is required to be on the Job Site full-time during the performance of the leak location survey.

1.7 SUBMITTALS

A. General: Submit each item in this Technical Specification in accordance with the conditions of the Agreement and Technical Specification 01 33 00 - Submittal Procedures.

B. Submittals relating to the geomembrane Manufacturer and geomembrane material:

1. Manufacturing:

a. List of material properties of the geomembrane material proposed for the Project meeting the requirements specified herein with attached certified test results.

b. Manufacturer's QC program and manual including description of in-house laboratory facilities.

c. A list of ten (10) completed facilities totaling a minimum of ten (10) million square feet, for which the Manufacturer has manufactured LLDPE and HDPE

geomembrane specified to be used on this Project. Provide the following information for each project:

(1). Name and purpose of the project, the project location, and date of installation.

(2). Name of the owner, project manager, design engineer, and installer.

(3). Geomembrane thickness and surface area.

d. Qualifications statement in accordance with Paragraph 1.6 of this Technical Specification.

e. Manufacturer's recommendations for geomembrane installation procedures.

f. Prior to transporting any geomembrane to the Job Site, the Manufacturer submits the following documentation on the geomembrane to the Owner:

1). The origin of the resin to be used in the manufacturing of the geomembrane to be used on the Project including the suppliers name and production plant, as well as brand name and tracking number.

2). Certification that no post-consumer reclaimed polymer is added to the resin during the manufacture of the geomembrane to be used in this Project. Rework of identical manufactured product is allowable up to a limit of seven (7) percent by weight.

3). Copies of QC certificates issued by the raw material supplier including the production dates of the raw material and the origin of the raw materials used to manufacture the geomembrane for the Project.

4). Copy of QC certificates in compliance with Paragraph 2.1C(1) of this Technical Specification that the LLDPE and HDPE geomembrane and extrudate produced for this Project have compatible properties. QC reports for the dates when the materials were produced for this Project.

C. Submittals relating to the Contractor's Installer:

1. Installation Capabilities:

a. Information on equipment and personnel.

b. Anticipated average daily production.

c. Number of crews employed and number available for this Work.

d. Qualifications in accordance with Paragraph 1.6 of this Technical Specification.

2. A list of five (5) completed projects totaling two (2) million square feet for which the Contractor's Installer has installed LLDPE and HDPE geomembrane specified to be used on this Project. Provide the following information for each project:

    a. Name and purpose of the project, the project location, and date of installation.

    b. Name of owner, design engineer, manufacturer, and name and telephone number of manufacturer's representative at the facility who can discuss the project.

    c. Surface area of the installed LLDPE and HDPE geomembrane.

    d. Type of seaming, patching and tacking equipment.

    e. A copy of the Manufacturer's certification or approval letter.

3. Project record (as-built) drawings reflecting the actual installation of the geomembrane, including the location of seams, the location of destructive samples, and the location of repair work.

D. Submittals relating to the Leak Location Subcontractor:

1. Leak Location Survey Work Plan including the following

    a. Qualifications of the Leak Location Subcontractor to include the number of years the Leak Location Subcontractor has performed the survey methods.

    b. Resumes of on-site supervisors.

    c. Description of the survey methods and procedures.

    d. Required site preparations.

    e. Estimated duration of the survey.

    f. Quality control and field calibration procedures.

    g. A list of projects demonstrating the qualifications and experience where the Leak Location Subcontractor and leak location supervisor have met the requirements of Paragraph 1.6C of this Technical Specification.

    h. Sample of a final report (per ASTM D7007-16) provided by the Leak Location Subcontractor following the completion of the survey.

E. Within thirty (30) Business Days prior to geomembrane installation submit the following:

1. Shop Drawings:

    a. Proposed panel layout for the LLDPE and the HDPE showing the installation layout identifying field seams as well as any variance or additional details which

deviate from the Project drawings. Indicate the geomembrane configuration, dimensions, details, locations of seams, etc. on these panel layout drawings. The panel layout drawings must be approved by the Owner prior to the installation of any geomembrane materials. Use the panel layout as an installation plan once approved by the Owner. The panel layout is considered part of the Project drawings.

b. Details of geomembrane seaming, anchoring, connections, penetrations and other construction details, which deviate from this Technical Specification.

2. Installation Quality Control:

a. A QC manual that specifically defines the QC program during installation for this Project. Include daily procedures, welding techniques, field testing procedures, lab testing procedures, specific steps that are to be taken in the event of a failure or defect, personnel requirements, levels of authority and other information necessary to ensure a high-quality geomembrane installation consistent with the Manufacturer recommendations and this Technical Specification in the manual.

b. Resume of the installation supervisor to be assigned to and on the Job Site during the Project.

c. Resume of the master seamer to be assigned to and on the Job Site during the Project.

d. A list of personnel performing installation and field seaming operations along with pertinent experience information.

(1). Seaming method and list of equipment to be used.

(2). Method and list of equipment for performing non-destructive seam tests.

(3). Submit a Certificate of Calibration, less than 12 months old, for the field tensiometer.

1.8 QUALITY CONTROL

A. In addition to Manufacturer and Contractor's Installer requirements for qualifications and certification specified in Paragraph 1.6 of this Technical Specification, QC consists of compliance testing of the material prior to delivery to the Job Site and field QC during installation.

B. Manufacturer compliance testing requirements are specified in Paragraph 2.2 of this Technical Specification. The purpose of compliance testing is to verify that the supplied material complies to the requirements of this Technical Specification and to the Manufacturer's QC certificates.

C. Field quality control testing requirements are specified in Paragraph 3.7 of this Technical Specification. The purpose of field QC procedures is to verify that the geomembrane

has been installed in accordance with the specifications and Manufacturer's recommendations.

D. Geomembrane QC Documentation:

1. Project Files:

a. Maintain two (2) duplicate Project files. One Project file is maintained by the Contractor and the other Project file is maintained by the Contractor's Installer. The Contractor's Installer provides the Contractor with complete daily documentation by the end of the following Business Day. At the end of each Work week, the Contractor and Contractor's Installer update and check the Project files to assure that copies of pertinent Project information are included in each file.

b. Make blank copies of the Project forms available on the Job Site throughout the duration of the Project.

1.9 DELIVERY, STORAGE AND HANDLING

A. Package and ship the geomembrane rolls by appropriate means to prevent damage of the geomembrane rolls. Off-loading, handling, and storage of the geomembrane is the responsibility of the Contractor's Installer. The Contractor's Installer is responsible for replacing any damaged or unacceptable geomembrane material.

B. Roll Identification: The Manufacturer provides geomembrane rolls marked or tagged with the following information:

1. Manufacturer's name.

2. Product identification.

3. Thickness.

4. Roll dimensions.

5. Manufacturer's roll and lot number.

6. Date of manufacture.

C Damage during off-loading is documented by the Contractor. Damaged geomembrane rolls must be separated from the undamaged geomembrane rolls and be removed by the Manufacturer from the Job Site.

D. Store the geomembrane roll to be protected from puncture, dirt, grease, water, mud, mechanical abrasions and excessive heat or cold that may damage the geomembrane material. Store the geomembrane rolls on a prepared surface (not wooden pallets or hard abrasive surfaces) and do not stack more than two (2) rolls high.

PART 2 PRODUCTS

2.1 MATERIALS

A. General:

1. Make the geomembrane with resin generally in the density range of 0.926 grams per cubic centimeter (g/cc) or lower and has a melt index value per ASTM D1238-13 of less than 1.0 grams per 10 minutes (g/10 min). Formulated sheet density is 0.939 g/cc or lower.

2. The blended resin contains two (2) to three (3) percent carbon black, anti-oxidants and heat stabilizer, but no fillers or extenders. The resin is virgin material, with no more than ten (10) percent rework. If rework is used, the rework must be of the same formulation as the parent material. No post-consumer resin of any type is to be added to the formulation.

3. Produce the geomembrane material free of holes, blisters, thin areas, inconsistent texturing, undispersed raw materials, or any sign of contamination by foreign matter.

4. Manufacture the sheets in a minimum 15-foot seamless width.

5. Manufacture the geomembrane in a single layer (welding thinner layers together to produce the required thickness is not allowed).

B. Properties:

1. The geomembrane rolls are textured LLDPE and HDPE meeting the specified physical, mechanical, and chemical property requirements listed in the attached Table 1 for LLDPE geomembrane and Table 2 for HDPE geomembrane. Conduct the manufacturing QC testing at the frequencies recommended in GRI GM 17 unless otherwise noted.

C. Other Materials:

1. Extrudate welding rods (for fusion welds) are compatible and similar to the geomembrane and supplied by the Manufacturer delivered in the original sealed containers. Label each container with a label bearing the brand name, Manufacturer's lot number, and complete directions as to proper storage.

2. Boots and shrouds for pipe penetration(s) to fit snugly around the pipe. Design prefabricated material to fit site-specific conditions for the intended slope and size of pipe and be made of compatible and identical materials as the geomembrane.

2.2 COMPLIANCE TESTING

A. Tests: Perform compliance testing by the independent QCL provided and paid for by the Contractor. Obtain the samples from the roll, mark the machine direction and identification number and ship the samples to the QCL by the Manufacturer. If appropriate arrangements are made with the Manufacturer, the QCL can go to the

Manufacturer's facility and obtain the required samples. Conduct the compliance tests at the laboratory prior to shipment of any material to the Job Site.

B. Frequency: Perform the compliance tests in accordance with the attached Table 1, Table 2, and Paragraph 2.3(A) of this Technical Specification for interface strength, at a frequency of one sample per 100,000 square feet unless otherwise noted or approved by the Owner.

C. Acceptance or Rejection: Prior to shipment of the geomembrane to the Job Site, the Contractor reviews the compliance test results for acceptance or rejection of the geomembrane material. Test results meet, or exceed, the property values listed in the attached Table 1 and Table 2 for acceptance of the geomembrane materials. The course of action implemented for retesting failing tests is approved by the Owner. In case of failing test results, the Manufacturer can request that another sample be retested by the independent laboratory with the Manufacturer's technical representative present during the testing procedures. The Manufacturer can also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results, the material is accepted. If both laboratories do not report passing results, geomembrane material from the lot or bracketed square footage representing the failing sample are considered out of specification and rejected for use on this Project.

2.3 SITE-SPECIFIC REQUIREMENTS

A. Conduct interface friction (direct shear) testing using site-specific soils. The test methods and required results are as presented in the attached Table 3.

PART 3 EXECUTION

3.1 PRE-INSTALLATION

A. Prior to implementing the Work within this Technical Specification, the Contractor's Installer carefully inspects the installation area and verifies that all Work is complete to the point where the installation of the geomembrane can properly commence without adverse impact.

B. If the Contractor's Installer has any concerns regarding the conditions where the geomembrane is to be installed, the Contractor's Installer notifies the Owner in writing prior to initiating the Work of this Technical Specification. Failure to inform the Owner in writing is not construed as the Contractor's Installer acceptance of the related Work of all other Technical Specifications.

3.2 SUBGRADE PREPARATION

A. Preparation of the subgrade for the cover system geomembrane (40-mil textured LLDPE geomembrane) and the liner system geomembrane (60-mil textured HDPE geomembrane and 60-mil textured LLDPE geomembrane) as specified in Technical Specification 31 20 00 - Earth Moving.

B. The surface of the subgrade is smooth, uniform, relatively free from abrupt changes in grade, rocks and stones greater than 3/8-inch for 40-mil LLDPE, 60-mil LLDPE, and 60-mil HDPE geomembrane, sharp objects, debris and deleterious materials. During actual placing and seaming of the geomembrane, keep the subgrade surface free of standing water. If the subgrade below the geomembrane becomes wet and unstable or cracked due to desiccation, re-work and re-compact the subgrade in accordance with Technical Specification 31 20 00 - Earth Moving. Before the geomembrane installation begins, the Contractor and the Contractor's Installer provide verification and sign off that the subgrade surface for the area to be lined has been inspected and properly prepared.

C. Repair of any damage to the subgrade surface caused by the geomembrane installation activities.

3.3 ANCHOR TRENCH

A. Excavate the anchor trench to the lines, grades, and dimensions as shown on the Project drawings and/or as specified herein.

B. Construct the anchor trench free of sharp edges or corners and maintain in a dry condition.

C. Adequately drain the anchor trench to prevent water ponding and softening of adjacent soils.

D. No loose soil is permitted beneath the geomembrane within the anchor trench.

E. Temporarily anchor geosynthetic material in the anchor trench with sandbags or other suitable materials until the anchor trench is backfilled.

F. Conduct backfilling of the anchor trench when the geomembrane is in the geomembrane's most contracted (taut) state.

G. Take care when backfilling and compacting the anchor trenches to prevent any damage to the geosynthetic materials.

3.4 GEOMEMBRANE PLACEMENT

A. Field Panel Layout Drawings: Produce geomembrane field panel layout drawing(s) as specified in Paragraph 1.7D(1)(a) of this Technical Specification by the Contractor's Installer.

B. Field Panel Identification: Each field panel is given an identification number. This identification number is agreed upon by the Owner and the Contractor's Installer and is shown on the field panel layout drawing.

1. Remove all labels from the geomembrane roll and/or packaging and submit to the Owner by the Contractor's Installer.

C. Method of Placement:

1. Roll out and install each panel of the geomembrane in accordance with the approved panel layout drawings prepared by the Contractor's Installer.

2. Design the panel layout to keep field seams of the LLDPE and HDPE geomembrane material to a minimum and consistent with proper methods of LLDPE and HDPE geomembrane installation.

3. Orient the panel layout and deployment parallel to the line of maximum slope (i.e., oriented down the slope; not across the slope).

4. Avoid end seams across slopes greater than 4:1 (4 horizontal and 1 vertical). See additional seam requirements in Paragraph 3.6 of this Technical Specification.

5. Place geomembrane rolls in a manner to prevent the material from being stretched during deployment.

6. Inspect each geomembrane panel, after placement and prior to seaming, for damage and/or defects. Also, inspect geomembrane panels prior to geocomposite drainage layer installation and the cushion geotextile installation. Replace or repair defective or damaged geomembrane panels in accordance with Paragraph 3.8 of this Technical Specification.

7. Avoid dragging the geomembrane sheets on rough soil subgrade.

8. Use a method to minimize wrinkles (especially differential wrinkles between adjacent panels) when placing the geomembrane panels.

9. Anchor the geomembrane as shown on the Project drawings and/or consistent with the Manufacturer's recommendations.

10. While working on the geomembrane, do not smoke, wear damaging shoes or perform any activity that can damage the geomembrane.

11. Properly weigh the edges and large exposed areas of the geomembrane to avoid uplift due to wind and to prevent lateral movement of the geomembrane.

12. Vehicular traffic except for proper installation vehicles (ATVs) across the geomembrane is not allowed. Obtain approval from the Owner for any vehicle used prior to or after geomembrane placement.

13. Record and indicate on the Project record (as-built) drawings the location of the repaired areas and the location of the destructive samples.

14. When tying into previously installed geomembrane, perform excavation adjacent to installed geomembrane by hand to prevent damage.

15. Keep the geomembrane free of debris, unnecessary tools and materials, and neat in appearance.

16. At a minimum, place a scrap geomembrane sheet beneath equipment necessary to perform the installation (generators, compressors, etc.) to protect the installed geomembrane from possible damage.

17. No welder or testing equipment is to remain on top of the installed geomembrane overnight. Remove and store equipment off the installed geomembrane.

18. Keep fuel containers off and perform no equipment fueling on top of the installed geomembrane.

D. Place sufficient slack in the geomembrane to compensate for the coldest temperatures envisioned so that no tensile stresses are generated in the geomembrane or in the seams either during installation or subsequently after the geomembrane is covered.

E. Provide adequate slack in the geomembrane such that the geomembrane does not lift off the subgrade or substrate material at any location within the liner/cover installation, i.e., no “trampolining” of the geomembrane is allowed to occur at any time.

F. Do not allow excessive slack in the geomembrane to the point where creases fold over upon themselves either during placement and seaming, or when the protective soil or drainage materials are placed on the geomembrane.

G. Permanent (fold-over type) creases in the covered geomembrane are not permitted.

H. The amount of slack to be added to the deployed and seamed geomembrane should be carefully considered and calculated, accounting for the type of geomembrane and the geomembrane’s temperature during installation versus the geomembrane’s final temperature in the completed installation.

I. Liner/Cover Penetrations:

1. Furnish and install LLDPE and HDPE boots or shrouds for liner/cover penetrations where indicated on the Project drawings. Design prefabricated material to fit site-specific conditions for the intended slope and size of pipe and be made of compatible and similar materials as the geomembrane.

2. Terminate the geomembrane end of the boots or shrouds in a skirt section suitable for welding to the geomembrane panel(s). Provide an approximate overlap of 18 inches between the boot or shroud and the geomembrane. Weld the boot or shroud to the geomembrane as specified herein.

3. Provide boots or shrouds that fit snugly around the pipe, pole, wells or vaults.

4. Use a neoprene rubber gasket and/or silicone caulking between the boot or shroud and the penetration structure and secure with a one (1)-inch wide stainless-steel clamp. Use a LLDPE or HDPE sacrificial geomembrane sheet between the boot or shroud and the clamp for protection.

5. For pipes, poles, wells, vaults larger than four (4)-inch diameter, use a second stainless steel clamp. Locate the fastener of the second stainless steel clamp on the opposite side from the first stainless steel clamp, to compensate for uneven pressure and elongation.

3.5 SEAMING WEATHER CONDITIONS

A. Weather Conditions for Geomembrane Seaming:

1. Normal Weather Conditions:

   a. Ambient temperature higher than 32 degrees F and lower than 104 degrees F unless otherwise authorized, in writing, by the Owner.

   b. No precipitation or other excessive moisture, such as fog or dew.

   c. No excessive winds.

   d. These weather conditions are obeyed throughout performance of the seaming process.

2. Cold Weather Conditions:

   a. If the ambient air temperature is below 32 degrees F, avoid geomembrane seaming.

      1). If geomembrane seaming in cold weather conditions is necessary, the Contractor's Installer can provide a separate plan demonstrating, to the satisfaction of the Owner, that geomembrane seam quality is not adversely impacted for review and approval by the Owner.

      2). Perform trial (test) seams under similar ambient air temperature conditions as the actual seams.

      3). Take additional destructive tests at the discretion of the Owner.

3. Warm Weather Conditions:

   a. If the ambient air temperature is above 104 degrees F, avoid geomembrane seaming.

      (1). If geomembrane seaming in warm weather conditions is necessary, the Contractor's Installer can provide a separate plan demonstrating, to the satisfaction of the Owner, that geomembrane seam quality is not adversely impacted for review and approval by the Owner.

      (2). Perform trial (test) seams under similar ambient air temperature conditions as the actual seams.

      (3). Take additional destructive tests at the discretion of the Owner.

3.6 FIELD SEAMING

A. Maintain at least one (1) spare operable seaming apparatus on the Job Site at all times.

B. Equip the seaming apparatus with fully operational controls, gauges, and monitoring devices applicable to all functions which regulate or affect the seaming process or quality.

C. Place any electric power generating equipment required for the seaming operations outside the geomembrane area or mount on pneumatic tires which distribute the equipment load such that no damage to the geomembrane or the underlying subgrade can result. Properly ground electric power generating equipment at all times during use.

D. Layout and overlap individual panels of geomembrane a minimum of four (4) inches for fusion welding and six (6) inches for extrusion welding prior to welding.

E. "Shingle" or "rain-lap" seams.

F. Clean the area to be welded and keep free of moisture, dust, dirt, debris of any kind, and foreign material which can adversely affect the formation of the seam.

G. Use double track hot wedge fusion welds for straight long seams to the maximum extent possible.

H. Use extrusion welds in areas inaccessible for double track hot wedge fusion welding, including patches, repairs and penetration boots.

I. Use welding equipment capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is fusing the geomembrane material so as to ensure that changes in environmental conditions do not affect the integrity of the weld.

J. Make trial seams, with passing results, as specified in paragraph 3.7 A of this Technical Specification, at the beginning of each seaming period for each production seaming apparatus used that day.

    1. To account for minor variations in conditions, the seamer can reduce the weld speed by a maximum of 15 percent without the need to perform additional trial seams.

K. No "fish mouths" or wrinkles are allowed within the seam area. Cut out "fish mouths" or wrinkles in the geomembrane material and apply a patch using extrusion welding in accordance with Paragraph 3.8(C) of this Technical Specification. Tightly bond welds upon completion of the Work. Replace or repair any geomembrane area showing injury due to excessive scuffing, puncture, or distress from any cause with an additional piece of geomembrane. The number of Do not exceed five (5) patches per 100-foot length of seam. If more than five (5) patches per 100-foot length are necessary, then remove the entire 100-foot length of seam. Cease further welding and notify the Owner.

L. Assign seams a seam number that corresponds with the panel layout numbers. Use the numbering system in the development of the Project record (as-built) drawings. Derive

the seam numbers from the combination of the two panel numbers that are to be welded together. Number patches, boots and repairs using a system that includes the panel number where the patch, boot or repair is located.

M. Double weld fusion welded "T" seams (i.e., the result of the geomembrane panels placed perpendicular to each other) where possible. Use the extrusion weld process for the second weld.

N. Keep extrudate free of dirt, dry and protected from damage.

O. If an extrusion welder is stopped for longer than one minute, purge the extrusion welder to remove heat degraded extrudate. Do not place purged extrudate on the installed geomembrane.

P. Extend panels placed on sloped surfaces (steeper than 4:1 (4 horizontal and 1 vertical)) a minimum of five (5) feet inward (on the flat) from the top of slope or edge of trench.

Q. Stagger end seams a minimum of five (5) feet in length between contiguous panels. No end seams are allowed on slopes 4:1 (4 horizontal and 1 vertical) or greater, unless otherwise approved by the Owner.

R. To prevent moisture buildup during fusion welding, place a movable protective layer of plastic (skid sheet) directly below each overlap of geomembrane that is to be seamed, if necessary.

S. Extend seam welds the full extent into the anchor trench.

T. Factory seams, field seams, and repair welds meet seam strength requirements specified in the attached Table 4.

3.7 FIELD QUALITY CONTROL

A. Start-Up Testing: Trial Seams

1. Fabricate trial seams from pieces of the actual geomembrane material to verify that seaming conditions are adequate for production seaming. Trial seams are identical to and made under the same conditions as actual seams. Trial seams are at least three (3)-feet (extrusion welds) to ten (10)-feet (double-track welds) long and one (1)-foot wide (after seaming) with the seam centered lengthwise on the sample.

2. Perform trial seams at the beginning of each seaming period and at least once each four (4) hours for each production seaming apparatus/seamer combination used that day under the same conditions as exist for the geomembrane welding.

3. Each seamer performs at least one (1) trial seam each day.

4. Mark the trial seam with the date, time of day, seamer's initials, temperature and speed settings (for fusion welds) or temperature and preheat settings (for extrusion welds), and machine number.

5. Provide a calibrated tensiometer on the Job Site before and during geomembrane installation for testing samples. Cut six (6), one (1)-inch wide specimens from each trial seam and test on the Job Site in the presence of the Owner (three (3) for peel and three (3) for shear strength) in accordance with the attached Table 4.

6. Test results which meet or exceed the performance criteria specified in the attached Table 4 are indicative of acceptable seams. Test results that do not meet the specified performance criteria are indicative of failed seams. Failure of one (1) or more test specimens from a given trial seam constitutes a failure of that seam.

7. Record formal results for each test and test results which indicate a failure of a trial seam(s) are orally reported to the Owner immediately.

8. In the event that a test specimen fails in the seam, prepare and test a new trial seam and new test specimen. Repeat this procedure until the seaming deficiencies are corrected and two consecutive successful trial seam tests are achieved.

9. The tensiometer used to test the trial seams is capable of maintaining a constant jaw separation rate and is adjustable to operate in the range from two (2) to 20 inches per minute.

10. After completion of the previously described tests, any remaining portions of the trial seam sample(s) can be discarded.

B. Non-Destructive Seam Testing:

1. Perform a non-destructive test on field seams over the full length of the seam. The purpose of this testing is to assure continuity and integrity of the seams. Use vacuum and air pressure tests for non-destructive testing. Use the vacuum test for extrusion welds. Use the air pressure test for double track fusion welds.

2. Perform non-destructive testing on a continuing basis as the seaming work progresses. To the greatest extent practicable, test the seams on the Business Day formed. At the latest, test the seams on the Business Day following the Business Day of formation.

3. Vacuum Testing:

   a. Equipment for testing extrusion seams is comprised of the following:

      1). A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly and a vacuum gauge.

      2). A vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

      3). A rubber pressure/vacuum hose with fittings and connections.

      4). A plastic bucket and wide paint brush or mop.

5). A soapy solution.

b. The following procedures are followed by the Contractor's Installer:

1). Trim away excess sheet overlap.

2). Clean the window, gasket surfaces, and check for leaks.

3). Energize the vacuum pump and reduce the tank pressure to approximately five (5) pounds per square inch (psi).

4). Wet a strip of geomembrane approximately 12-inches by 48-inches (length of box) with the soapy solution.

5). Place the box over the wetted area and compress.

6). Close the bleed valve and open the vacuum valve.

7). Ensure that a leak-tight seal is created.

8). For a minimum period of ten (10) seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

9). If no bubbles appear after ten (10) seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum of three (3)-inch overlap and repeat the process.

10). Mark and repair areas where soap bubbles appear in accordance with Paragraph 3.8 of this Technical Specification and then retest.

c. If the seam is not accessible to vacuum box equipment and cannot be tested prior to final installation, the seaming operations are observed by the Owner for uniformity and completeness.

4. Air Pressure Testing (for double track fusion seams only):

a. Use equipment and procedures for non-destructive test methods as described in GRI-GM6.

b. Equipment for testing double fusion seams is comprised of the following:

1). An air pump equipped with pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi and mounted on a cushion to protect the geomembrane.

2). A manometer equipped with a sharp hollow needle, or other-approved pressure feed device.

c. The following procedures are followed by the Contractor's Installer:

1). Seal both ends of the seam to be tested. The length of seam cannot exceed 500 feet without approval by the Owner.

2). Insert the needle or other-approved pressure feed device into the tunnel created by the double wedge fusion weld.

3). Energize the air pump to a pressure between 25 psi and 30 psi. After allowing two (2) minutes for relaxation, monitor the pressure over a test period not less than five (5) minutes.

4). If the loss of pressure exceeds four (4) psi or the pressure does not stabilize, the weld is considered faulty (unless the Contractor's Installer can demonstrate that monitoring for an additional five (5) minutes does not cause an additional loss in pressure greater than one (1) psi, and that the pressure stabilizes within the second monitoring period). Locate the faulty area, repair in accordance with Paragraph 3.8 of this Technical Specification and retest.

5). If the pressure loss is less than four (4) psi after five (5) minutes, cut the air channel on the opposite end of the pressure device to confirm there is no blockage and verify the length of the seam tested. Remove the needle or other approved pressure feed device and seal the penetrations with an extrusion welded patch in accordance with Paragraph 3.8 of this Technical Specification.

C. Destructive Seam Testing

1. Purpose: The purpose of the destructive testing is to evaluate seam strength properties.

2. Sampling Frequency: An initial minimum sampling interval of one test per 500 linear feet of performed seam length is used for a minimum start-up batch of 25 samples. With zero (0) to one (1) failures out of 25 samples, the sampling interval can be increased to a maximum of one (1) test per 1,500 feet of seam length with the approval of the Owner. With more than two (2) failures out of 25 samples, the sampling interval can be decreased as determined by the Owner.

   a. Collect at least one (1) sample for each seaming crew for each Business Day of welding.

3. Sample Locations: The location of samples is determined by the Owner. Selection of such locations can be prompted by suspicion of overheating, contamination, or other potential cause that can adversely impact the welds. Do not reveal the location of the samples to Contractor's Installer in advance. Sampling is performed by the Contractor's Installer.

4. Sampling Procedures:

   a. Cut the samples by the Contractor's Installer at locations chosen by the Owner as the seaming progresses.

b. Do not cover the seams by another material before the seams have been tested and accepted by Owner.

c. Upon obtaining each sample, the Owner performs the following:

1). Assign a number to the sample and mark the sample accordingly.

2). Record sample location on the field panel layout drawing(s).

3). Record purpose of the sample, statistical routine, or suspicious weld area.

4). Observe field tensiometer testing performed by the Contractor's Installer and record the test data.

d. Immediately repair holes in the geomembrane resulting from destructive seam sampling in accordance with Paragraph 3.8 of this Technical Specification. The continuity of the new seams in the repaired area are non-destructively tested.

5. Size and Disposition of Samples:

a. The destructive samples are a minimum of 12 inches wide by approximately 48 inches long with the seam centered lengthwise.

1). Take two (2) samples, 12 inches wide by six (6) inches from each end of the sample for field testing.

2). Cut each of these samples with a one (1) inch wide die, with the seam centered parallel to the width.

3). If all samples pass the field test described in Paragraph 3.7(C)(6) of this Technical Specification, take a sample for laboratory testing from the remaining 36 inch sample.

4). The Owner logs the date, name of seamer, number of seaming units, and pass or fail description of the field test.

b. Cut the remaining 36 inch sample into three (3) parts and distributed as follows:

1). One portion to the Contractor's Installer for optional laboratory testing, 12 inches by 12 inches.

2). One portion for QCL testing, 12 inches by 12 inches.

3). One portion to the Owner for archive storage, 12 inches by 12 inches.

6. Field Testing:

a. Perform the following by the Contractor's Installer in the presence of the Owner:

1). Cut six (6) one (1)-inch wide replicate specimens from the field testing samples to be tested for shear and peel strength in accordance with the criteria set in the attached Table 4.

2). Test three (3) specimens for shear seam strength and three (3) specimens for peel strength. Replicate test specimens must pass for the seam to be acceptable.

3). Test the samples with a tensiometer equipped with a drive/pull apparatus adjusted to a pull rate of 20 inches per minute for both peel and shear testing in accordance with ASTM D6392-12. Test each sample until film tearing bond (FTB) is achieved. At a minimum, the required pass criteria for peel and shear is as specified in the attached Table 4.

(Note: The machine is capable of pulling the geomembrane seams at either two (2) or 20 inches per minute at the start of the first production Business Day. If the results are similar, both numerically and visually, the specified test speed is 20 inches per minute for all field and laboratory destructive seam tests. If it appears that the faster speed can be affecting the testing results, then the specified speed is two (2) inches per minute for all field and laboratory destructive seam testing.)

4). Any specimen that fails through the weld or through the fusion at the weld sheet interface is a non-FTB break and is be considered a failure even if the specimen achieves the acceptable strengths.

5). A specimen that does not break at the full extent of the test apparatus is considered a passing test.

6). Alternate testing to evaluate both sides of dual wedge welds.

7. Quality Control Laboratory Testing:

a. Package and ship, by the Contractor's Installer, destructive test samples to the Contractor's independent QCL as directed by the Owner by overnight delivery service. Shipping costs and destructive tests are to be paid by the Contractor.

b. Perform laboratory testing to include shear and peel strength tests performed in accordance with ASTM D6392-12. The minimum acceptable values obtained in these tests is in accordance with the attachedTable 4.

c. Test at least five (5) specimens each for shear and peel strength. A passing test meets the minimum required values in the five (5) specimens tested for each method.

d. Provide verbal test results from the QCL to the Owner no more than 24 hours after the QCL receives the samples. The Owner reviews the laboratory results as soon as the results become available.

8. Procedures for Destructive Test Failure:

   a. Apply the following procedures whenever a sample fails a destructive test, whether that test is conducted in the field or by the QCL. The Contractor's Installer has two options:

      1). The Contractor's Installer can cap strip the seam between the failed location and two (2) passed laboratory test locations, or the beginning or end of that day's seaming. Cap stripping involves applying a strip of geomembrane, a minimum distance of six (6) inches on all sides of the defective seam(s) and seaming the cap strip to the sheet material by extrusion welding. Non-destructively test the cap strip extrusion weld using the vacuum box method for the total weld.

      2). The Contractor's Installer can retrace the welding path to an intermediate location a minimum of ten (10) feet on each side of the failed test location. Take a minimum of two (2) eight (8) inch by 12-inch samples for additional field testing. If these additional samples pass the field tests, then specimens are laboratory tested for confirmation and the seam is reconstructed between the passing laboratory test locations. Subsequent failure of test samples causes the testing to move further down the seam until the extent of faulty seam has been determined.

   b. In any case, acceptable repaired seams are bound by two passing locations on each side of the original sample. In cases where repaired seam exceeds 150 feet, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Make repairs in accordance with Paragraph 3.8 of this Technical Specification.

   c. Document all actions taken in conjunction with destructive test failures by the Owner.

3.8 DEFECTS AND REPAIRS

A. Repair any portion of the geomembrane exhibiting signs of any kind of defect or failing a destructive or a non-destructive test. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure is made by the Owner.

   1. All repairs are subject to the same performance criteria and QA/QC monitoring and testing requirements as the original geomembrane installation.

   2. Repairs which fail to meet the QA/QC test requirements are redone and retested until a compliant repair is achieved.

B. The repair procedures available include:

   1. Patching: Used to repair large holes, tears, undispersed raw materials and impacts by foreign matter.

2. Spot Welding or Seaming: Used to repair small tears, pinholes, or other minor, localized defects.

3. Cap Strips: Used to repair large lengths of failed seams.

4. Seam Removal: Removing bad seam and replacing with a strip of new material welded in place.

C. For any repair method, satisfy the following provisions:

1. Abrade surfaces of the geomembrane which are to be repaired using extrusion methods no more than one (1) hour prior to making the repair.

2. Clean and dry the surfaces at the time of making the repair.

3. Qualify the seaming equipment used in repair procedures.

4. Extend the patches and caps at least four (4) inches beyond the edge of the defect.

5. Cut patches with rounded corners.

6. Non-destructively test each repair using the methods described in Paragraph 3.7B of this Technical Specification, as appropriate.

   a. Repairs which pass the non-destructive test are accepted as an adequate repair.

7. Repairs more than 150 feet long are of sufficient length to require destructive test sampling at the discretion of the Owner.

   a. A failed test of the repaired section indicates that the repair is redone and retested until passing test results are achieved.

8. Non-destructive and destructive testing of repairs are observed by the Owner.

D. Wrinkles: Large wrinkles that remain in the sheet as result of temperature expansion or uneven surface preparation need to be removed as determined by the Owner in consideration of applied loads on the wrinkle. Should the wrinkle need to be removed, cut the lower downslope edge of the wrinkle, overlapped, and repair as described in Paragraph 3.8C of this Technical Specification. Patch both ends of the wrinkle repair. Caution must be taken in removing any wrinkles.

E. Repair Records Verification

1. Number, log, and test each repair. Lay out, dimension, and number repairs on the appropriate field panel drawing(s).

2. Identify the nature of the defect, describe the repair affected, the date the repair was performed, and list the results of tests performed to verify the conformance of the repair with this Technical Specification in the repair log.

3.9 GEOMEMBRANE COVER

A. Install the following components of the final cover system and the liner system as specified upon receiving QC approvals and the Owner's approval of the geomembrane installation.

1. Final Cover System Geocomposite: The geocomposite drainage layer (GDL) is placed directly over the geomembrane in accordance with Technical Specification 31 05 19.26 - Geocomposites of the Technical Specifications.

2. Process Pond Liner System Geotextile: The cushion geotextile is placed directly over the geomembrane in accordance with Technical Specification 31 05 19.13 – Geotextiles.

3. Landfill Modification Liner System Geocomposite: The geocomposite drainage layer (GDL) is placed directly over the geomembrane in accordance with Technical Specification 31 05 19.26 - Geocomposites of the Technical Specifications.

3.10 GEOMEMBRANE LEAK TESTING

A. Required information:

1. The Contractor provides the following information to the Leak Location Subcontractor:

   a. All layers constituting the Landfill Modification bottom liner system.

   b. Details of all geomembrane penetrations.

   c. Peripheral details, including welds to adjacent lining systems.

   d. Structures and obstructions above the geomembrane.

   e. Electrical equipment above the geomembrane.

B. Site Preparation by the Contractor:

1. The Contractor performs activities provided by the Leak Location Subcontractor to prepare the Job Site for the leak location survey.

2. Ensure that the gypsum materials above the geomembrane and the earth materials below the geomembrane contain sufficient moisture to conduct a leak location survey. Typically, a moisture content of one (1) to two (2) percent by weight is sufficient to conduct the survey. If the moisture content of the gypsum/earth materials layer is not sufficient per the requirements of Leak Location Subcontractor, then add sufficient water to the gypsum/earth materials, as required.

3. Provide electrical isolation around the perimeter of the area being surveyed for leaks. Electrical isolation is achieved by leaving approximately a one (1)-foot wide area of dry geomembrane exposed around the perimeter of the survey area or

leaving a minimum of six (6)-inches of bare geomembrane protruding from the back-filled anchor trench. Isolate any other electrically conducting paths through the geomembrane such as metal pipes, battens, or concrete structures.

C. Execution by the Leak Location Subcontractor:

1. Furnish equipment for performing the Work that automatically records and stores the leak location survey data in electronic format at the time of data collection (continuous survey data recording) and that can be post-processed for data plotting and analysis.

2. Inspect the Job Site prior to commencing the leak location survey to ensure all Job Site preparations are completed and the Job Site conditions are appropriate for conducting the leak location survey.

3. Report to the Contractor any discrepancy in the required Job Site preparations described in the Leak Location Survey Work Plan or Job Site conditions for corrective or appropriate action.

4. After the protective cover component of the bottom liner/leachate collection system is installed above the geocomposite, conduct a leak location survey using the procedures for leak location surveys with materials covering the geomembrane described in the latest version of ASTM D7007-16.

5. Automatically record and store the survey data in electronic format at the time of data collection. Provide a data acquisition system with digital data transfer from the measurement electronics to a computer to eliminate human error.

6. Inform the Contractor and mark the locations of all identified or indicated leaks with markers, flags, spray paint, or written coordinates.

D. Reporting

1. Provide a written report within 14 Days of completion of the leak location survey field work as described in ASTM D7007-16, as applicable.

3.11 GEOMEMBRANE ACCEPTANCE

A. The Contractor's Installer retains all ownership and responsibility for the geomembrane until accepted by the Owner.

B. Acceptance of the geomembrane by the Owner occurs when:

1. The geomembrane installation is completed.

2. All documentation related to the geomembrane installation is completed, including the Owner's final report.

3. Verification of the adequacy of all field seams and repairs is completed.

4. Written certification documents, sealed by the Owner, and including project record (as-built) drawings, prepared and sealed by the Contractor's Installer, have been received by the Owner.

3.11 DISPOSAL OF TRASH AND EXCESS MATERIAL

A. Upon completion of geomembrane installation, properly remove and dispose of all trash, excess waste material, tools, and equipment used in connection with the performed Work and leave the premises in a neat and acceptable condition.

3.12 PROJECT RECORD (AS-BUILT) DRAWINGS AND INSTALLATION DOCUMENTATION

A. Prepare and submit, by the Contractor's Installer, to the Contractor a project record (as-built) drawing(s) reflecting the actual installation of the geomembrane materials, including the location of seams, the location of destructive samples, and the location of repair work in accordance with Technical Specification 01 78 39 - Project Record Documents. Submit the project record (as-built) drawing(s) to the Contractor within seven (7) Business Days of the completion of the geomembrane installation. In addition, a copy of the complete installation documentation package accompanies the project record (as-built) drawing(s).

END OF SECTION

Table 1. Material Properties: Linear Low-Density Polyethylene (LLDPE) Geomembrane – Textured (both sides) Sheet

Property	Units	Test Method	Value	Value	Frequency
Thickness – specified	Mils	ASTM D5994/D5994M-10(2015)e1	40	60	Every Roll
Thickness – min. average roll value (MARV)	Mils		38	57	
Lowest individual for 8 of 10 values	Mils		36	54	
Lowest individual for any 10 values	Mils		34	51	
Asperity Height (min. ave.)(1,2)	Mils	ASTM D7466/D7466M-10(2015)e1	18	18	Every Roll
Tensile Properties (min. ave.)(3)		ASTM D6693/D6693M-04(2015)e1 (Type IV)			20,000 lbs
1. Break Strength	lb/in		60	90	
2. Break Elongation	%		250	250	
Tear Resistance (min. ave.)	lb	ASTM D1004-13	22	33	45,000 lbs
Puncture Resistance (min. ave.)	lb	ASTM D4833/D4833M-07(2013)e1	48	66	45,000 lbs
Axi-Symmetric Break Resistance Strain (min.)	%	ASTM D5617-04(2015)	30	30	Per formulation
Density (max.)	g/cc	ASTM D1505-10/ASTM D792-13	0.939	0.939	200,000 lbs
Carbon Black Content (range)	%	ASTM D1603-14	2.0 to 3.0	2.0 to 3.0	45,000 lbs
Carbon Black Dispersion	NA	ASTM D5596-03(2016)	Note 5	Note 5	45,000 lbs
Oxidative Induction Time (OIT) (min. ave.)(6)					200,000 lbs
Standard OIT or	%	ASTM D3895-14	100	100	
High Pressure OIT	%	ASTM D5885/D5885M-15	400	400	
Oven Aging at 85 º C retained after 90 days (min. ave.)(6)					Per formulation
Standard OIT or	%	ASTM D3895-14	35	35	
High Pressure OIT	%	ASTM D5885/D5885M-15	60	60	
UV Resistance – High Pressure OIT – retained after 1600 hours (min. ave.)(7,8)	%	ASTM D5885/D5885M-15	35	35	Per formulation

Notes:

1. Of 10 readings, 8 of 10 must be ≥ 7 mils, and the lowest individual reading must be ≥ 5 mils.
2. Alternate the measurement side for double sided textured sheet.
3. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five test specimens each direction. Break elongation is calculated using a gage length of 2.0 inches at 2.0 inch/min.
4. Other methods such as ASTM D4218-15 (muffle furnace) or microwave methods are acceptable, if an appropriate correlation to ASTM D1603-14 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.
6. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
7. The condition of the test should be 20 hour UV cycle at 75º C followed by four-hour condensation at 60º C.
8. UV resistance is based on percent retained value regardless of the original HP-OIT value.
9. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.

min. – minimum; ave. – average; lb/in – pounds per inch; % - percent; lb – pounds; lbs – pounds; g/cc – grams per cubic centimeter; max. – maximum; UV – ultraviolet; ASTM - American Society for Testing and Materials

The above tests are performed by the Manufacturer of the LLDPE geomembrane for identification of the Manufacturer's product. Submit the test results to the Contractor for approval of the product. The LLDPE geomembrane supplied for the Project meets these properties.

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Table 2. Material Properties: High Density Polyethylene (HDPE) Geomembrane – Textured (both sides) Sheet

Property	Units	Test Method	Value	Frequency
Thickness – specified	Mils	ASTM D5994/D5994M-10(2015)e1	60	Every Roll
Thickness – min. average roll value (MARV)	Mils		57	
Lowest individual for 8 of 10 values	Mils		54	
Lowest individual for any 10 values	Mils		51	
Asperity Height (min. ave.)(1,2)	Mils	ASTM D7466/D7466M-10(2015)e1	18	Every Roll
Density (max.)	g/cc	ASTM D1505-10/ASTM D792-13	0.940	200,000 lbs
Tensile Properties (min. ave.)(3)		ASTM D6693/D6693M-04(2015)e1 (Type IV)		20,000 lbs
1. Yield Strength	lb/in		126	
2. Break Strength	lb/in		90	
3. Yield Elongation	%		12	
4. Break Elongation	%		100	
Tear Resistance (min. ave.)	lb	ASTM D1004-13	42	45,000 lbs
Puncture Resistance (min. ave.)	lb	ASTM D4833/D4833M-07(2013)e1	90	45,000 lbs
Carbon Black Content (range)	%	ASTM D1603-14	2.0 to 3.0	20,000 lbs
Carbon Black Dispersion	NA	ASTM D5596-03(2016)	Note 5	45,000 lbs
Oxidative Induction Time (OIT) (min. ave.)(6)				200,000 lbs
Standard OIT	min.	ASTM D3895-14	100	
High Pressure OIT	min.	ASTM D5885/D5885M-15	400	
Oven Aging at 85 ° C retained after 90 days (min. ave.)(6)				Per formulation
Standard OIT	%	ASTM D3895-14	55	
High Pressure OIT	%	ASTM D5885/D5885M-15	80	
UV Resistance – High Pressure OIT – retained after 1600 hours (min. ave.)(7,8)	%	ASTM D5885/D5885M-15	50	Per formulation

Notes:
1. Of 10 readings, 8 of 10 must be ≥ 7 mils, and the lowest individual reading must be ≥ 5 mils.
2. Alternate the measurement side for double sided textured sheet.
3. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five test specimens each direction. Break elongation is calculated using a gage length of 2.0 inches at 2.0 inch/min.
4. Other methods such as ASTM D4218-15 (muffle furnace) or microwave methods are acceptable, if an appropriate correlation to ASTM D1603-14 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.
6. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
7. The condition of the test should be 20 hour UV cycle at 75° C followed by four-hour condensation at 60° C.
8. UV resistance is based on percent retained value regardless of the original HP-OIT value.
9. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.

min. – minimum; ave. – average; lb/in – pounds per inch; % - percent; lb – pounds; lbs – pounds; g/cc – grams per cubic centimeter; max. – maximum; UV – ultraviolet; ASTM - American Society for Testing and Materials

The above tests are performed by the Manufacturer of the HDPE geomembrane for identification of the Manufacturer's product. Submit the test results to the Contractor for approval of the product. The HDPE geomembrane supplied for the Project meets these properties.

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Table 3. Linear Low-Density Polyethylene (LLDPE) Geomembrane – Interface Friction (Direct Shear) Testing

Property	Units	Test Method	Value	Frequency[a]
Interface – Geocomposite/Geomembrane[b][c]	degrees	ASTM D5321/D5321M-14	Peak = 26[d] Residual = 22.5[d]	One per interface
Interface – Geomembrane/Subgrade Soil[b][c]	degrees	ASTM D5321/D5321M-14	Peak = 26[d] Residual = 22.5[d]	One per interface

Notes:

(a) Conduct the site-specific testing at the frequency of 1 test/100,000 square feet unless otherwise noted.

(b) Perform interface tests at normal stresses of 1, 2, and 4 pounds per square inch (psi) with a displacement rate of 0.04 inches per minute (in/min), under wet conditions, report peak and residual values.

(c) Provide site-specific soils (Common Fill) to the QC Laboratory along with the Manufacturer provided site-specific geocomposite.

(d) For cohesion/adhesion intercept = 0 pounds per square-foot (psf). Interface friction values less than those specified, but containing cohesion/adhesion can be evaluated for acceptance by the Owner.

GDL – geocomposite drainage layer; ASTM - American Society for Testing and Materials; SF – square feet

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Table 4. Seam Properties: Linear Low-Density Polyethylene (LLDPE) Geomembrane and High Density Polyethylene (HDPE) Geomembrane – Textured (both sides) Sheet

Property	40 Mil LLDPE	60 Mil HDPE	Test Method
Peel Strength (Extrusion) Peel Strength (Fusion)	44 ppi 50 ppi	78 ppi 91 ppi	ASTM D6392-12
Shear Strength (Extrusion and Fusion)	60 ppi	120 ppi	ASTM D6392-12

Notes:

ppi – pounds per inch; ASTM - American Society for Testing and Materials

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SECTION 31 05 19.19

GEOGRIDS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Agreement and Division 01 Technical Specifications, apply to this Technical Specification.

1.2 SUMMARY

A. This Technical Specification covers furnishing all labor and equipment for installation of Contractor-supplied geogrid material for the Project. Use the geogrid material to "bridge" and provide strength to weak yielding area(s) as follows:

1. The subgrade component (CCR material and/or the combination of CCR material and soil borrow material) of the final cover system associated with the CCR Impoundment Closure.

2. The subgrade or fill component of the final graded surface associated with the Main Ash Pond Riser Demolition and the West Collection Basin Demolition.

B. Perform or cause the performance of all laboratory quality control (QC) testing as specified herein. Field/laboratory quality assurance (QA) testing is performed by the Owner.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Technical Specification 01 11 00 – Summary of Work

B. Technical Specification 01 33 00 - Submittal Procedures

C. Technical Specification 31 20 00 – Earth Moving

1.4 REFERENCES

A. The publications listed below, latest edition unless otherwise noted, form a part of this Technical Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM)

1. ASTM D5262-07(2016) Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics

2.	ASTM D6637/D6637M-15	Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method
3.	ASTM D6706-01(2013)	Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
4.	ASTM D7737/D7737M-15	Standard Test Method for Individual Geogrid Junction Strength
5.	ASTM D7748/D7748M-14e1	Standard Test Method for Flexural Rigidity of Geogrids, Geotextiles, and Related Products
6.	ASTM D864/D7864M-15	Standard Test Method for determining the Aperture Stability Modulus of Geogrids

C. Geosynthetic Research Institute (GRI) Standards

1.	GRI GG4(a)	Determination of the Long-Term Design Strength of Stiff Geogrids

1.5 DEFINITIONS AND RESPONSIBILITIES

A. Contractor: The Contractor is the firm or corporation with whom the Owner has entered the Agreement to perform the Work on the Project. The Contractor is responsible for the following as required by this Technical Specification:

3. Purchasing and furnishing the geogrid materials including appurtenances required for this Project.

4. Review of submittals by the Manufacturer and the Contractor's Installer.

5. Scheduling and coordination of the required Work with the Manufacturer and the Contractor's Installer to complete the Project.

6. Oversees the installation of the geogrid by the Contractor's Installer.

7. Inspections and reviewing testing results for compliance with the specified requirements.

8. Compiles the QA test results daily and documents the QA activities in weekly reports.

B. Manufacturer: The Manufacturer is the firm or corporation contracted by the Contractor for production of the geogrid material to be used in the Project. The Manufacturer produces a consistent product meeting or exceeding the specifications and provides QC documentation for the product(s) specified herein.

C. Quality Control Laboratory: An independent Quality Control Laboratory (QCL) hired by the Contractor to perform compliance testing of the geogrid material with demonstrated qualifications for conducting required testing.

D. Construction Quality Assurance (CQA): CQA inspections are conducted by an independent third party specializing in geomembrane quality assurance/quality control (QA/QC). The CQA monitor collects samples and conducts independent QA testing.

1.6 QUALIFICATIONS

A. Manufacturer: Demonstrate the Manufacturer's ability to produce the geogrid by having at least five (5) years continuous experience in the manufacturing of geogrid and successfully manufactured a minimum of ten (10) million square feet of similar material for geogrid installations.

1.7 SUBMITTALS

A. General: Submit each item in this Technical Specification in accordance with the Conditions of the Agreement and Technical Specification 01 33 00 - Submittal Procedures.

B. Submittals relating to the geogrid Manufacturer and the geogrid material:

1. Manufacturing:

a. List of material properties of the geogrid proposed for the Project meeting the requirements specified herein with attached certified test results.

b. Manufacturer's QC program and manual including description of in-house laboratory facilities.

c. A list of ten (10) completed projects totaling a minimum of ten (10) million square feet, for which the Manufacturer has manufactured the geogrid specified to be used on this Project. Provide the following information for each project:

(1) Name and purpose of project, the project location, and date of installation.

(2) Name of the owner, project manager, design engineer, and installer.

(3) Geogrid type and surface area.

d. Qualifications statement in accordance with Paragraph 1.6 of this Technical Specification.

e. Manufacturer's recommendations for geogrid installation procedures.

1.8 QUALITY CONTROL

A. In addition to Manufacturer's requirements for qualifications and certification specified in Paragraph 1.6 of this Technical Specification, QC consists of compliance testing of the material prior to delivery to the Job Site and field QC during installation.

B. Manufacturer compliance testing requirements are specified in Paragraph 2.3 of this Technical Specification. The purpose of compliance testing is to verify that the supplied material complies to the requirements of this Technical Specification and to the Manufacturer's QC certificates.

C. Geogrid QC Documentation:

1. Project Files:

a. Maintain two (2) duplicate Project files. One Project file is maintained by the Contractor and the other Project file is maintained by the Owner. The Contractor provides the Owner with complete daily documentation by the end of the following Business Day. At the end of each Work week, the Contractor updates and checks the Project files to assure that copies of pertinent Project information are included in each file.

b. Make blank copies of the Project forms available on the Job Site throughout the duration of the Project.

1.9 DELIVERY, STORAGE AND HANDLING

A. Package and ship the geogrid rolls by appropriate means to prevent damage of the geogrid rolls. Off-loading, handling, and storage of the geogrid is the responsibility of the Contractor. The Contractor is responsible for replacing any damaged or unacceptable geogrid material.

B. Roll Identification: The manufacturer provides geogrid rolls marked or tagged with the following information:

1. Manufacturer's name.

2. Product identification.

3. Thickness.

4. Roll dimensions.

5. Manufacturer's roll and lot number.

6. Date of manufacture.

C. Damage during off-loading is documented by the Contractor. Damaged geogrid rolls must be separated from the undamaged geogrid rolls and removed by the Manufacturer from the Job Site.

D. Store the geogrid rolls to be protected from dirt, grease, water, mud, mechanical abrasions and excessive heat or cold that may damage the geogrid material. Store the geogrid rolls on a prepared surface (not wooden pallets or hard abrasive surfaces) and do not be stacked more than five (5) rolls high.

PART 2 PRODUCTS

2.1 MATERIAL

A. Geogrid products are of high density polyethylene or polyester yarns encapsulated in a protective coating specifically fabricated for use as a soil reinforcement material.

2.2 MANUFACTURING QUALITY CONTROL

A. Manufacture the geogrid in accordance with the Manufacturer's QC Plan submitted to and approved by the Owner.

B. Geogrid material in non-compliance with this Technical Specification is subject to rejection.

2.3 COMPLIANCE TESTING

A. Tests: Perform compliance testing by an independent QCL provided and paid for by the Contractor. Obtain the samples from the geogrid roll, mark the machine direction and identification number and ship the samples to the QCL by the Manufacturer. If appropriate arrangements are made with the Manufacturer, the QCL can go to the Manufacturer's facility and obtain the required samples. Performed the compliance tests for the geogrid material properties listed in the attached Table 1.

B. Frequency: Perform the compliance tests in accordance with Table 1 at a frequency of one sample per 100,000 square feet unless otherwise noted or approved by the Owner.

C. Acceptance or Rejection: Prior to shipment of the geogrid to the Job Site, the Owner reviews the compliance test results for acceptance or rejection of the geogrid materials. Test results must meet, or exceed, the property values listed in Table for acceptance of the geogrid. The course of action implemented for retesting failing tests is approved by the Owner. In case of failing test results, the Manufacturer can request that another sample be retested by the independent laboratory with the Manufacturer's technical representative present during the testing procedures. The Manufacturer can also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results, the material is accepted. If both laboratories do not report passing results, the geogrid material from the lot or bracketed square footage representing the failing sample is considered out of specification and rejected for use on this Project.

PART 3 EXECUTION

3.1 SHIPMENT AND STORAGE

A. During all periods of shipment and storage, protect the geogrid from direct sunlight, ultraviolet rays, temperature greater than -20° F, mud, dirt, dust and debris. To the extent possible, maintain the geogrid wrapped in a heavy duty protective covering until

installed. Geogrid can be used up to six (6) months from direct exposure to sunlight without any loss in certifiable structural properties.

3.2 EARTHWORK

A. Surface Preparation:

1. Lightly proof roll the subgrade to determine the limits of the unsuitable materials.

2. Smooth grade and compact to the degree practicable using appropriate compaction equipment.

3. Crown the surface for positive drainage away from the soft and yielding area.

3.3 INSTALLATION

A. Prior to implementing any of the Work described in this Technical Specification, become thoroughly familiar with all portions of the Work described within this Technical Specification and related Technical Specifications.

B. Placement:

1. Adhere to the Manufacturer's recommendations and this Technical Specification during installation of the geogrid.

2. Handle the geogrid in such a manner as to ensure the geogrid is not damaged in any way.

3. Place the geogrid roll(s) in position, cut the roll bands, and manually unroll the material over the prepared subgrade.

   a. Remove all labels from the geogrid roll and/or packaging and submit to the Owner.

   b. To the greatest extent practicable, orient the geogrid sheets parallel to the line of maximum slope, i.e., oriented down, not across, the slope.

   c. Overlap the geogrids such that the downgradient geogrid sheet is placed under the upgradient geogrid sheet creating the overlap.

   d. Install the geogrids with a minimum overlap of 24 inches for geogrid placed on slopes less than 4H:1V.

      1). The Manufacturer's recommendations for overlap requirements apply, if the Manufacturer's recommendations for overlap requirements are more stringent.

   e. When required cut the geogrid to extend a minimum of three (3) feet beyond the edge of the soft and yielding area of the subgrade.

4. While not normally an issue, in the presence of wind weigh down the geogrid with sand bags or the equivalent. Installed the sand bags during placement and the sand bags remain until replaced with overlying layers of coarse material above the completed geogrid installation.

5. Examine the entire geogrid surface after installation to ensure that no potentially harmful foreign objects are present. Remove foreign objects and replace damaged geogrid.

Tensioning and Pinning:

1. Before fully unrolling the geogrid, anchor the beginning of the roll in the center and at the corners to the underlying subgrade.

2. Align the geogrid sheet and pull the sheet taut to remove wrinkles and laydown slack with hand tension; then secure in place.

3. Anchor with small piles of aggregate material or washers and pins. Large heavy-gauge staples can be used by driving the staples into the subgrade through the apertures of the grids.

C. Dumping and Spreading Aggregate Fill:

1. Place an initial lift of aggregate fill material not less than six (6) inches in thickness. For very soft subgrade conditions, increase the initial lift thickness to 12 inches.

2. Back trucks up over competent subgrade and dump aggregate fill at the edge of the soft and yielding area of the subgrade.

3. Use a light weight low ground pressure (LGP) dozer to evenly push out the aggregate fill over the exposed geogrid. The desired effect is aggregate fill that cascades onto the geogrid, rather than the aggregate fill being pushed into the geogrid.

4. Take care not to catch the dozer blade or other equipment on the geogrid. Raise the dozer blade gradually as each aggregate fill lift is pushed out over the geogrid.

5. Be aware of the overlaps and advance the aggregate fill lift with the shingle pattern.

D. Compacting:

1. Use standard compaction methods unless subgrade is very soft and yielding. In these cases, use static equipment instead of vibratory.

2. For construction over very soft subgrade, reduce compaction requirements of the initial lift to achieve a suitable working surface.

3. Keep the moisture content of the aggregate fill near optimum.

E. Repairs:

1. Repair damaged geogrid during or after installation as follows:

   a. Remove the aggregate fill from the surface of the damaged geogrid and clear a three (3) foot area around the damaged geogrid.

   b. Place a geogrid patch over the damaged area and extend a minimum of three (3) feet beyond the damaged area in all directions.

3.4 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus geogrid and waste materials, including trash, and debris, and legally dispose of off the Owner's property.

END OF SECTION

Table 1. Minimum Physical Properties - Geogrid

Property	Units	Test Method	Value				Frequency
			Longitudinal	Diagonal	Transverse	General	
Rib Pitch(1)	inch		1.30 – 1.60	1.30 – 1.60			Every 50,000 SF
Mid-Rib Depth(1)	inch			0.05	0.05		Every 50,000 SF
Mid-Rib Width(1)	inch			0.04	0.04		Every 50,000 SF
Rib Shape						Rectangular	Every 50,000 SF
Aperture Shape						Triangular	Every 50,000 SF
Junction Efficiency(2)	%	ASTM D6637/D6637M-15				93	Every 50,000 SF
Isotropic Stiffness Ratio(3)						0.6	Every 50,000 SF
Radial Stiffness at Low Strain(4)	lb/ft@ 0.5% strain	ASTM D6637/D6637M-15				13,708 – 15,430	Every 50,000 SF
UV Resistance(5)	%	ASTM D4355/D4355M-14				70	Every 50,000 SF
Resistance to Chemical Degradation(6)	%					100	Every 50,000 SF

Notes:

1. Nominal dimensions.
2. Load transfer capability determined in accordance with ASTM D6637/D6637M-15 and expressed as a percentage of ultimate tensile strength.
3. The ratio between the minimum and maximum observed valves of radial stiffness at 0.5 percent strain, measured on rib and midway between rib directions.
4. Radial stiffness is determined from tensile stiffness measured in any in-plane axis from testing in accordance with ASTM D6637/D6637M-15.
5. Resistance to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and aggressive weathering in accordance with ASTM D4355/D4355M-14.
6. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments in accordance with EPA 9090 immersion testing.

SF – square feet; % - percent; lb/ft – pound feet; ASTM - American Society for Testing and Materials

The above tests are performed by the Manufacturer of the geogrid for identification of the Manufacturer's product. Submit the test results to the Owner for approval of the product. The geomembrane supplied for the Project meets these properties.

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SECTION 31 05 19.23

GEOSYNTHETIC CLAY LINERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Agreement and Division 01 Technical Specifications, apply to this Technical Specification.

1.2 SUMMARY

A. This Technical Specification covers the technical requirements for the manufacturing and installation of the fabric encased geosynthetic clay liner (GCL) as follows:

1. Positioned below the High Density Polyethylene (HDPE) geomembrane and above low permeability soil material functioning as the composite barrier layer for the Process Pond liner system as shown on the Project drawings.

2. Positioned below the Linear Low Density Polyethylene (HDPE) geomembrane and above low permeability soil material functioning as the composite barrier layer for the Landfill Modification liner system as shown on the Project drawings.

B. All materials meet or exceed the requirements of this Technical Specification, and all Work is performed in accordance with the procedures provided in this Technical Specifications including furnishing labor, materials, equipment and incidentals required to install the GCL.

C. Perform or cause the performance of all laboratory quality control (QC) testing and field/laboratory quality assurance (QA) testing as specified herein.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Technical Specification 01 11 00 – Summary of Work

B. Technical Specification 01 33 00 - Submittal Procedures

C. Technical Specification 01 78 39 - Project Record Documents

D. Technical Specification 31 05 19.16 – Geomembranes

E. Technical Specification 31 20 00 – Earth Moving

F. Technical Specification 33 05 33.16 – High Density Polyethylene (HDPE) Pipe

1.4 REFERENCES

A. The publications listed below, latest edition unless otherwise noted, form a part of this Technical Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM)

1. ASTM D4632/D4632M-15a	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
2. ASTM D4643-08	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating
3. ASTM D5084-16a	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
4. ASTM D5261-10	Standard Test Method for Measuring Mass Per Unit Area of Geotextiles
5. ASTM D5321/D5321M-14	Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
6. ASTM D5887/D5887M-16	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter
7. ASTM D5888-06(2016)	Standard Guide for Storage and Handling of Geosynthetic Clay Liners
8. ASTM D5889/D5889M-16	Standard Practice for Quality Control of Geosynthetic Clay Liners
9. ASTM D5890-11	Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
10. ASTM D5891/D5891M-02(2016)e1	Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
11. ASTM D5993-14	Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners
12. ASTM D6102-15	Standard Guide for Installation of Geosynthetic Clay Liners

13. ASTM D6243/D6243M-16	Standard Test Method for Determining the Internal and Interface Shear Strength of Geosynthetic Clay Liner by the Direct Shear Method
14. ASTM D6496/D6496M-02A(2015)e1	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
15. ASTM D6766-12	Standard Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Aqueous Solutions
16. ASTM D6768/D6768M-04(2015)e2	Standard Test Method for Tensile Strength of Geosynthetic Clay Liners
17. ASTM E96/E96M-16	Standard Test Methods for Water Vapor Transmission of Materials

C. Geosynthetic Research Institute (GRI) Standards

1. GRI GCL3	Standard Specifications for Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners

D. Relevant publications from the Environmental Protection Agency (EPA): Daniel, D.E. and R.M. Koerner, (1993), Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

1.5 DEFINITIONS AND RESPONSIBILITIES

A. Contractor: The Contractor is the firm or corporation with whom Owner has entered the Agreement to perform the Work on the Project. The Contractor is responsible for the following as required by this Technical Specification:

1. Purchasing and furnishing the GCL materials including appurtenances required for this Project.

2. Review of submittals by the Manufacturer and the Contractor's Installer.

3. Scheduling and coordination of the required Work with the Manufacturer and the Contractor's Installer to complete the Project.

4. Oversees the installation of the GCL by the Contractor's Installer.

5. Inspections and reviewing testing results for compliance with the specified requirements.

6. Compiles the QA test results daily and documents the QA activities in weekly reports.

B. Manufacturer: The Manufacturer is the firm or corporation contracted by the Contractor for production of the GCL material to be used in the Project. The Manufacturer produces a consistent product meeting or exceeding the specifications and provides QC documentation for the product(s) specified herein.

C. Contractor's Installer: The Contractor's Installer is the firm or corporation contracted by the Contractor for installation of the GCL. The Contractor's Installer can be the Manufacturer or a Manufacturer-approved installer trained and certified to install the Manufacturer's GCL. The Contractor's Installer is responsible for field handling, storing, placing, seaming, sampling, testing, protecting and other aspects of the GCL installation.

D. Quality Control Laboratory: An independent Quality Control Laboratory (QCL) hired by the Contractor to perform compliance testing of the GCL material with demonstrated qualifications for conducting required testing.

E. Construction Quality Assurance (CQA): CQA inspections are conducted by an independent third party specializing in GCL quality assurance/quality control (QA/QC). The CQA monitor collects samples and conducts independent QA testing.

F. Sodium Bentonite – The high swelling clay component of GCLs consisting primarily of the mineral Montmorillonite.

G. Thermal Fusing – A needle punching enhancement process utilizing heat to bond the needle punched fibers and more permanently lock them into the second geotextile to increase the internal shear strength characteristics.

1.6 QUALIFICATIONS

A. Manufacturer: Demonstrate the Manufacturer's ability to produce the GCL material by having at least five (5) years continuous experience in the manufacturing of GCL material and successfully manufactured a minimum of ten (10) million square feet of similar material for hydraulic barrier installations.

B. Contractor's Installer: The Contractor's Installer can be the Manufacturer or a manufacturer approved installer trained to install the Manufacturer's GCL. Perform installation under the constant direction of a single installation supervisor who remains on the Job Site and is in responsible charge through the Process Pond subgrade soil approval, GCL layout, GCL installation, overlap, patching, testing, repairs and other Job Site activities required by the Contractor's Installer.

1. The Contractor's Installer has installed a minimum of two (2) million square feet of GCL in the last five (5) years.

2. The Contractor's Installer has worked in a similar capacity on at least five (5) projects similar in complexity to the Project described in the Agreement, and with at least two (2) million square feet of GCL installation on each project.

3. The installation supervisor has worked in a similar capacity on projects similar in size and complexity to the Project described in the Agreement.

1.7 SUBMITTALS

A. General: Submit each item in this Technical Specification in accordance with the conditions of the Agreement and Technical Specification 01 33 00 - Submittal Procedures.

B. Submittals relating to the GCL Manufacturer and GCL material:

1. Manufacturing:

a. List of material properties of the GCL material proposed for the Project meeting the requirements specified herein with attached certified test results.

b. Manufacturer's QC program and manual including description of in-house laboratory facilities.

c. A list of ten (10) completed facilities totaling a minimum of ten (10) million square feet, for which the Manufacturer has manufactured the GCL material specified to be used on this Project. Provide the following information for each project:

(1). Name and purpose of the project, the project location and date of installation.

(2). Name of the owner, project manager, design engineer and installer.

(3). GCL type and surface area.

d. Qualifications statement in accordance with Paragraph 1.6 of this Technical Specification.

e. Manufacturer's recommendations for GCL installation procedures.

f. Prior to transporting any GCL material to the Job Site, the Manufacturer submits the following documentation on the GCL material to the Owner:

(1). Copies of quality control certificates issued by the raw material supplier including the production dates of the raw material and the origin of the raw materials used to manufacture GCL material for the Project.

(2). Test results conducted by the Manufacturer to verify the sodium bentonite quality used to manufacture the GCL rolls assigned to the Project and the sodium bentonite origin, along with quality control certificates issued by the sodium bentonite supplier.

(3). Roll numbers and identification.

(4). Copies of the QC test results, including descriptions of test methods used.

(5). The Manufacturer quality control tests to be performed are outlined in Paragraph 2.3 of this Technical Specification.

C. Submittals relating to the Contractor's Installer:

1. Installation Capabilities:

   a. Information on equipment and personnel.

   b. Anticipated average daily production.

   c. Number of crews employed and number available for this Work.

   d. Qualifications in accordance with Paragraph 1.6 of this Technical Specification.

2. A list of five (5) completed projects totaling two (2) million square feet for which the Contractor's Installer has installed the type of GCL material specified to be used on this Project. Provide the following information for each project:

   a. Name and purpose of the project, the project location and date of installation.

   b. Name of owner, design engineer, manufacturer and name and telephone number of manufacturer's representative at the facility who can discuss the project.

   c. Surface area of the installed GCL.

   d. A copy of the manufacturer's certification or approval letter.

3. The Installation Supervisor has worked in a similar capacity on projects similar in size and complexity to the Project described in the Agreement and this Technical Specification.

4. Contractor's Installer, through the Contractor, submits to the Owner the following information upon completion of the GCL installation:

   a. Certificate stating the GCL has been installed in accordance with the Agreement and this Technical Specification.

   b. GCL material and installation warranties.

   c. Project record (as-built) drawings showing actual GCL placement including typical anchor trench detail.

1.8 QUALITY CONTROL

A. In addition to Manufacturer and Contractor's Installer requirements for qualifications and certification specified in Paragraph 1.6 of this Technical Specification, QC consists of compliance testing of the material prior to delivery to the Job Site and field QC during installation.

B. Manufacturer compliance testing requirements are specified in Paragraph 2.5 of this Technical Specification. The purpose of compliance testing is to verify that the supplied material complies to the requirements of this Technical Specification and to the Manufacturer's QC certificates.

C. Field QC testing requirements are specified in Paragraph 3.6 of this Technical Specification. The purpose of field QC procedures is to verify that the GCL has been installed in accordance with the requirements of this Technical Specification and the Manufacturer's QC recommendations.

D. GCL QC Documentation:

1. Project Files:

   a. Maintain two (2) duplicate Project files. One Project file is maintained by the Contractor and the other Project file is maintained by the Contractor's Installer. The Contractor's Installer provides the Contractor with complete daily documentation by the end of the following Business Day. At the end of each Work week, the Contractor and Contractor's Installer update and check the Project files to assure that copies of pertinent Project information are included in each file.

   b. Make blank copies of the Project forms available on the Job Site throughout the duration of the Project.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package and ship the GCL rolls with a waterproof plastic covering by appropriate means to prevent damage of the GCL rolls. Off-loading, handling, and storage of the GCL is the responsibility of the Contractor's Installer. The Contractor's Installer is responsible for replacing any damaged or unacceptable GCL material.

1. Ship less than one (1)-month prior to scheduled installation unless otherwise approved by the Owner.

B. Roll Identification: The Manufacturer provides GCL rolls marked or tagged with the following information:

1. Manufacturer's name.

2. Product Identification.

3. Roll dimensions: length and width

4. Roll Number

5. Date of manufacture.

C. Storage

1. Store the GCL rolls in a location provided by the Contractor to protect the GCL from abrasions, dirt and moisture with the following characteristics:

   a. Level (no wooden pallets).

   b. Smooth.

   c. Dry.

   d. Protected from theft and vandalism.

   e. Adjacent to the installation area.

2. Store the GCL rolls elevated above the ground surface.

3. Stack no more than three rolls high.

4. Protect rolls from UV, precipitation, other sources of moisture, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

5. Use an additional tarpaulin or plastic over the stacked rolls to provide extra protection for GCL material stored outdoors.

6. Preserve integrity and readability of roll labels.

7. Store and tarp the bagged bentonite material next to the GCL rolls unless other more protective measures are available. Store the bags on pallets or other suitably dry surface which prevents undue prehydration.

D. Handling

1. Note any visible damage to the GCL materials on the Bill of Lading prior to unloading the GCL rolls. Should any visible damage be noted, immediately notify the Manufacturer in writing.

2. Handle the GCL rolls in such a manner to ensure the GCL rolls are not damaged in any way. Repair minor rips or tears in the plastic packaging with moisture sensitive tape prior to being placed in storage to prevent moisture damage.

PART 2 PRODUCTS

2.1 SODIUM BENTONITE

A. General:

1. The sodium bentonite is a uniform layer of premium naturally-occurring Wyoming sodium bentonite which has been polymer enhanced.

2. Polymers which are biological in nature are not approved. Do not use Bi-polymer (complex polysaccharides or sugars) thickening agents such as guar and xanthan gum. These agents are subject to degradation by micro-organisms indigenous to soil and water.

3. The sodium bentonite is not adversely affected when immersed in a leachate representative of that from a typical coal combustion residual (CCR) landfill or slurry impoundment.

4. Use the same granular bentonite as used in the production of the GCL itself for accessory bentonite used for sealing seams, penetrations, or repairs.

B. Properties:

1. The sodium bentonite meets the specified physical, mechanical, and chemical property requirements listed in attached Table 1.

2.2 SODIUM BENTONITE ENCAPSULATION

A. General:

1. Encapsulated the sodium bentonite between a nonwoven and a scrim-nonwoven geotextile for dimensional stability.

2. Mechanically bond, by needle punching, the two geotextiles together to achieve fabric encapsulation. The needle punch process thermally heat sets the non-woven fibers where the fibers protrude from the second geotextile (woven or nonwoven fibers depending on product) to more permanently secure the reinforcement in place.

3. No broken needles or fragments are allowed as a result of the fabric encapsulation process. Use continuous needle detection and removal devices during GCL product manufacturing.

4. The nonwoven needle punched geotextile specified herein is made from staple fiber.

5. The geotextile is made from prime quality virgin polymer.

6. The geotextile is able to withstand direct exposure to ultraviolent radiation from the sun for up to 30 days without any noticeable effect on index or performance properties.

7. Factory seaming is not allowed.

2.3 GCL

A. General:

1. Manufacture the GCL by mechanically bonding the geotextiles using an encapsulation process as described in Paragraph 2.2 of this Technical Specification to enhance frictional and internal shear strength requirements.

2. In order to maintain these characteristics, no glues, adhesives or other non-mechanical bonding processes are used in lieu of the needle punch process. Their use to enhance the physical properties of the GCL is permitted.

3. The minimum acceptable dimensions for the GCL panels is 15 feet wide and 150 feet in length. Short rolls (rolls less than 150 feet in length) can be supplied, but at a rate not to exceed five (5) percent of the total square footage produced for this Project.

4. Imprint a minimum overlap guide-line and a construction match-line delineating the overlap zone with non-toxic ink on both edges of the GCL panel to ensure the accuracy of the seam. Use these lines during CQA to ensure the minimum overlap is achieved. The minimum overlap guideline indicates where the edge of the panel must be placed in order to achieve the correct overlap for each panel.

5. The GCL seam overlaps are a minimum of six (6)-inches for all woven/nonwoven GCLs. GCL's comprised of nonwoven/nonwoven geotextiles have a minimum seam overlap of six-(6) inches for scrim reinforced and a 12-inch overlap minimum for all non-scrim reinforced nonwoven GCLs. End of panel or butt end seams are a minimum of 12-inches for all woven/nonwoven GCLs, 12-inches for all scrim-reinforced double nonwoven GCLs, and 24-inches for non-scrim reinforced double nonwoven GCLs.

B. Properties:

1. The GCL specified are GSE Coal Ash Resistant NWL BentoLiner, CETCO Continuum DN.

2. The GCL meets the specified physical, mechanical, and chemical property requirements listed in attached Table 2 of this Technical Specification.

2.4 MANUFACTURING QUALITY CONTROL

A. Manufacture the GCL in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the Owner.

B. GCL material in non-compliance with these specifications is subject to rejection.

C. Broken needles and/or fragments in the GCL is cause for rejection.

2.5 COMPLIANCE TESTING

A. Tests: Perform compliance testing by the independent QCL provided and paid for by the Contractor. The Manufacturer obtains the samples from the roll, mark the machine direction and identification number and ship the samples to the QCL. If appropriate arrangements are made with the Manufacturer, the QCL can go to the Manufacturer's facility and obtain the required samples. Conduct the compliance tests at the laboratory prior to shipment of any material to the Job Site.

B. Frequency: Perform these compliance tests in accordance with Table 1 and Paragraph 2.6(A) of this Technical Specification for interface strength, at a frequency of one (1) sample per 100,000 square feet unless otherwise noted or approved by the Owner.

C. Acceptance or Rejection: Compliance test results are reviewed by the Owner and accepted or rejected, prior to shipment of the GCL material to the Job Site. Test results meet or exceed the property values listed in Table 1 of this Technical Specification. The Owner approves the course of action implemented for retesting failing tests. In case of failing test results, the Manufacturer may request that another sample be retested by the independent laboratory with the Manufacturer's technical representative present during the testing procedures. The Manufacturer may also have the sample retested at two (2) different laboratories approved by the Owner and paid for by the Manufacturer. If both laboratories report passing results, the material is accepted. If both laboratories do not report passing results, the GCL material from the bracketed square footage representing the failing sample is considered out of specification and rejected.

2.6 SITE-SPECIFIC REQUIREMENTS

A. Conduct interface friction (direct shear) testing using site-specific soils. The test methods and required results are as presented in attached Table 3 of this Technical Specification.

PART 3 EXECUTION

3.1 PRE-INSTALLATION

A. Hold a GCL Pre-Construction Meeting at the Job Site prior to installation of the GCL. At a minimum, attendance by the Contractor's Installer, Owner, Owner Engineer, and the Contractor is required.

B. Prior to implementing the Work of this Technical Specification, the Contractor's Installer carefully inspects the installed Work of all other Technical Specifications and verifies that the Work is complete to the point where the installation of this Technical Specification may properly commence without adverse impact.

C. If the Contractor's Installer has any concerns regarding the installed Work of other Technical Specifications, the Contractor's Installer notifies the Owner.

3.2 SUBGRADE PREPARATION

A. Preparation of the subgrade for the Process Pond liner system GCL is as specified in Technical Specification 31 20 00 - Earth Moving.

B. The surface of the subgrade is smooth, uniform, relatively free from abrupt changes in grade, wheel ruts, roots, sticks, rocks and stones greater than one-inch for GCL, sharp objects, debris and deleterious materials.

C. At a minimum, prior to initating GCL deployment, the subgrade is proof-rolled using a smooth drum roller such that installation equipment and other construction vehicle traffic do not cause rutting greater than one (1)-inch deep. Furthermore, remove, crush, or push into the subgrade protrusions extending more than one half-inch from the subgrade.

D. Maintain the subgrade in this condition and free of standing water throughout the GCL deployment.

E. If the subgrade below the GCL becomes wet and unstable or cracked due to desiccation, re-work the subgrade and re-compacted in accordance with Technical Specification 31 20 00 - Earth Moving.

F. Before the GCL installation begins, the Contractor and the Contractor's Installer verifys and signs off that the subgrade surface for the area to be lined has been inspected and properly prepared.

1. It is the Contractor's Installer's responsibility to communicate to the Owner of any changes in the condition of the subgrade that might render the subgrade out of compliance with any of the requirements of this Technical Specification or ASTM D6102-15, Paragraph D.

G. Repair any damage to the subgrade surface caused by the GCL installation activities.

3.3 ANCHOR TRENCH

A. Excavate the anchor trench to the lines, grades, and dimensions shown on the Project drawings and/or as specified herein.

B. Construct the anchor trench free of sharp edges or corners and maintain in a dry condition.

C. Construct the anchor trench to adequately drain in order to prevent water ponding and softening of adjacent soils.

D. No loose soil is permitted beneath the GCL within the anchor trench.

E. The anchor trench is inspected and approved by the Owner prior to GCL placement and backfilling and compaction of the anchor key material.

F. Use care when backfilling and compacting the anchor trench to prevent any damage to the GCL material.

G. Standard Anchor - Place the GCL into and across the base of the excavated trench, stopping at the back wall of the excavation

H. Anchor the GCL material installed on slopes to prevent potential GCL panel movement.

3.4 GCL PLACEMENT

A. Visually inspect the GCL during deployment for imperfections and mark faulty or suspect areas.

B. The Contractor's Installer maintains a daily field record of the actual placement of each GCL panel, noting the weather conditions, seaming, parameters, samples taken, and tests run. The Contractor's Installer provides a copy of the field record to the Owner no later than the following Day.

1. Remove all labels from the GCL roll and/or packaging and submit to the Owner by the Contractor's Installer.

C. Unroll the GCL using methods that does not damage the GCL and protects the underlying surface from damage.

D. GCL panels are typically placed with the nonwoven side up (heat burnished side down) to maximize the shear strength characteristics. However, place the heat burnished side up, if this placement maximizes the shear strength characteristics of a site-specific interface shear. In base or flat areas, the GCL does not require any particular orientation.

E. Where possible, install all slope panels parallel to the maximum slope while panels installed in flat areas require no particular orientation.

F. Conduct deployment on flat areas in the same manner as that for the slopes, however, take care to minimize "dragging" the GCL. A slip-sheet is used to facilitate positioning of the GCL while ensuring the GCL is not damaged from underlying sources.

G. Install the GCL materials in general accordance with the procedures set forth in this Technical Specification, subject to site-specific conditions which would necessitate modifications.

H. Proceed with deployment from the highest elevation to the lowest to facilitate drainage in the event of precipitation.

I. The GCL is deployed on slopes by pulling the material from a suspended roll, or securing a roll end into an anchor trench and unrolling each panel as the handling equipment slowly moves backwards.

J. Do not allow heavy vehicular traffic directly on the GCL. Rubber-tired ATV's and trucks are acceptable, if wheel contact is less than eight (8) pounds per square inch (psi).

K. Protect GCL in areas of heavy traffic by placing at least 12-inches of protective cover over the GCL.

L. Place the geomembrane over the GCL in a manner that prevents damage in accordance with the GCL Manufacturer's installation guidelines. Proceed immediately with

placement of the geomembrane over the GCL following the placement and inspection of the GCL to prevent premature hydration.

3.5 SEAMS AND OVERLAPS

A. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.

B. Extend slope seams (panels) a minimum of five (5)-feet beyond the grade break into the flat area.

3.6 FIELD QUALITY ASSURANCE

A. The Manufacturer and the Contractor's Installer participate in and comply with all terms and requirements of the Owner's quality assurance program. The Contractor is responsible for assuring this participation.

3.7 REPAIR PROCEDURES

A. Prior to covering the deployed GCL, inspect each roll for damage resulting from installation. Damage is defined as any rips or tears in the geotextiles, delamination of geotextiles, premature hydration of the GCL, or a displaced panel.

B. Remove damaged GCL and replace with acceptable GCL materials, if damage cannot be satisfactorily repaired.

C. Repair any portion of unsatisfactory GCL or seam area as determined by the Owner.

D. Contractor's Installer is responsible for repair of unsatisfactory areas.

E. Rips or tears are 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 can be left in place), with a minimum overlap of 12-inches on all edges. Accessory bentonite is 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 six (6)-inch fillet.

F. Damaged GCL material on slopes is repaired by the same procedures; however, the edges of the patch is also be adhered to the repaired GCL with an adhesive or heat tack welded to keep the patch in position during backfill or cover operations.

G. Displaced panels are adjusted to the correct position and orientation. The adjusted panel is then inspected for any geotextile damage or bentonite loss. Damage is repaired as outlined by the procedures specified in this Technical Specification.

H. If the GCL is prematurely hydrated greater than 30 percent moisture, the Contractor's Installer notifys the Owner for a site specific determination as to whether the material is acceptable or if alternative measures must be taken to ensure the quality of the installation.

I. Record the number and log repair (performed by Owner) for each GCL panel.

END OF SECTION

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Table 1. Material Properties: Sodium Bentonite

Property	Units	Test Method	Value	Frequency
Moisture Content	% max	ASTM D4643-08	25	1/1000,000 lb
Swell Index	ml/2g min	ASTM D5890-11	24	1/1000,000 lb
Fluid Loss	l max	ASTM D5891/D5891M-02(2016)e1	18	1/1000,000 lb

Notes:

min. – minimum; max. – maximum; % - percent; lb – pounds; lbs – pounds; g – grams; ml – milliliters; l - liters

The above tests are performed by the Manufacturer of the GCL for identification of the Manufacturer's product. Submit the above test results to the Contractor for approval of the product. The GCL to be supplied for the Project meets these properties.

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Table 2. Material Properties: Geosynthetic Clay Liner (GCL)

Property	Units	Test Method	Value	Frequency
Geotextile				
Cap, Non-woven	oz/yd^2	ASTM D5261-10	6.0[1]	1/200,000 SF
Carrier Scrim, Non-woven	oz/yd^2	ASTM D5261-10	6.0[1]	1/200,000 SF
Finished GCL				
Bentonite[2]	psf	ASTM D5993-14	0.75[1]	1/40,000 SF
Tensile Strength[3]	lb/in	ASTM D6768/D6768M-04(2015)e2	45[1]	1/40,000 SF
Peel Strength	lb/in lbs	ASTM D6496/D6496M-04A(2015)e1 ASTM D4632/D4632-15a[4]	3.5[1] 21[1]	1/40,000 SF
Hydraulic Conductivity[5]	m/sec	ASTM D5887/D5887M-16	5x10^{-9}	1/Week
Index Flux[5]	m^3/m^2/sec	ASTM D5887/D5887M-16	1x10^{-8}	1/Week
Internal Shear Strength[6]	psf	ASTM D6243/D6243M-16	500	Periodically
Roll Dimensions				
Width x Length	ft x ft	NA	15.5 x 150	Every Roll
Area per Roll	SF	NA	2,325	Every Roll
Packaged Weight	lbs	NA	2,600	Every Roll

Notes:

1. Minimum Average Roll Value
2. Oven-dried measurement. Equates to 0.84 lb/ft (4.1 kg/m) when indexed to 12 percent moisture content
3. Tested in machine direction
4. Modified ASTM D4632/D4632-15a to use a four inch (100 mm) wide grip. The maximum peak of five specimens averaged in machine direction
5. Deaired, deionized water at 5 psi (34.5 kPa) maximum effective confining stress and 2 psi (13.8 kPa) head pressure
6. Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf (9.6 kPa) normal stress
7. Roll widths and lengths have a tolerance of ±1 percent

oz/yd^2 – ounces per square yard; SF – square feet; psf – pounds per square foot; lb/in – pounds per inch; lbs – pounds; m/sec – meters per second; m^3/m^2/sec – cubic meters per square meters per second; ft – feet; ASTM - American Society for Testing and Materials

Perform the above tests by the Manufacturer of the GCL for identification of the Manufacturer's product. Submit the above test results to the Contractor for approval of the product. The GCL to be supplied for the Project meets these properties.

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Table 3. GCL – Interface Friction (Direct Shear) Testing

Property	Units	Test Method	Value	Frequency
Interface – GCL/Geomembrane[(a)(b)]	degrees	ASTM D5321/D5321M-14	Peak = 26[(c)] Residual = 22.5[(c)]	1/100,000 SF
Interface – GCL/Soil[(a)(b)]	degrees	ASTM D5321/D5321M-14	Peak = 26[(c)] Residual = 22.5[(c)]	1/100,000 SF

Notes:

(a) Perform interface tests at normal stresses of 1, 2, and 4 pounds per square inch (psi) with a displacement rate of 0.04 inches per minute (in/min), under wet conditions, report peak and residual values.
(b) The Contractor provides site-specific soils (Common Fill) to the Quality Control Laboratory along with the Manufacturer provided site-specific geocomposite.
(c) For cohesion/adhesion intercept = 0 pounds per square-foot (psf). Interface friction values less than those specified, but containing cohesion/adhesion is evaluated for acceptance by the Owner.

GDL – geocomposite drainage layer; ASTM - American Society for Testing and Materials; SF – square feet

Submit the above test results to the Contractor for approval of the product. The GCL to be supplied for the Project meets these properties.

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SECTION 31 05 19.26

GEOCOMPOSITES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Agreement and Division 01 Technical Specifications, apply to this Technical Specification.

1.2 SUMMARY

A. This Technical Specification covers the technical requirements for the manufacturing and installation of the double-sided geocomposite drainage layer (GDL) as follows:

1. Positioned above the geomembrane functioning as the drainage layer for the CCR Impoundment Closure final cover system as shown on the Project drawings.

2. Positioned above the geomembrane functioning as the leachate collection layer the the Phase 1 Landfill Modification leachate management system as shown on the Project drawings.

3. Positioned above the geomembrane functioning as the drainage layer for the Phase 1 and Phase 3 Landfill Modification final cover systems as shown on the Project drawings.

B. Furnish all materials to meet or exceed the requirements of this Technical Specification, and perform all Work in accordance with the procedures provided in the Technical Specifications including furnishing labor, materials, equipment, and incidentals required to install the geocomposite as part of the final cover system and leachate management system construction.

C. Perform or cause the performance of all laboratory quality control (QC) testing and field/laboratory quality assurance (QA) testing as specified herein.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Technical Specification 01 11 00 – Summary of Work

B. Technical Specification 01 33 00 - Submittal Procedures

C. Technical Specification 31 05 19.13 – Geotextiles

D. Technical Specification 31 05 19.16 - Geomembranes

E. Technical Specification 31 20 00 – Earth Moving

1.4 REFERENCES

A. The publications listed below, latest edition unless otherwise noted, form a part of this Technical Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM)

1. ASTM D1505-10	Standard Test Method for Density of Plastics by the Density-Gradient Technique
2. ASTM D1603-14	Standard Test Method for Carbon Black Content in Olefin Plastics
3. ASTM D1621-16	Standard Test for Compressive Properties of Rigid Cellular Plastics
4. ASTM D4218-15	Standard Test Method for determination of Cabon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
5. ASTM D4355/D4355M-14	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus
6. ASTM D4491/D4491M-16	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
7. ASTM D4716/D4716M-14	Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
8. ASTM D4751-16	Standard Test Methods for Determining Apparent Opening Size of a Geotextile
9. ASTM D4833/D4833M-07(2-13)e1	Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
10. ASTM D5035-11(2015)	Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
11. ASTM D5101-12	Standard Test Method for Measuring the Filtration Compatibility of Soil-Geotextile Systems
12. ASTM D5199-12	Standard Test Method for Measuring Nominal Thickness of Geosynthetics
13. ASTM D5261-10	Standard Test Method for Measuring Mass per Unit Area of Geotextiles

14. ASTM D5321/D5321M-14	Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
15. ASTM D6363-06(2011)	Standard Test Method for Determining Short-Term Compression Behavior of Geosynthetics
16. ASTM D7005/D7005M-16	Standard Test Method for Determining The Bond Strength (Ply-Adhesion) of Geocomposites
17. ASTM D7179-07(2013)	Standard Test Method for determining Geonet Breaking Force
18. ASTM D7361-07(2012)	Standard Test Method for Accelerated Compressive Creep of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method
19. ASTM D7406-07(2012)	Standard Test Method for Time-Dependent (Creep) Deformation Under Constant Pressure for Geosynthetic Drainage Products

C. Canadian General Standards Board (CAN/CGSB): 148.1 No. 10-94 Methods of Testing Geosynthetics Geotextiles – Filtration Opening Size

D. Relevant publications from the Environmental Protection Agency (EPA): Daniel, D.E. and R.M. Koerner, (1993), Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

1.5 DEFINITIONS AND RESPONSIBILITIES

A. Contractor: The Contractor is the firm or corporation with whom Owner has entered the Agreement to perform the Work on the Project. The Contractor is responsible for the following as required by this Technical Specification:

1. Purchasing and furnishing the geocomposite materials including appurtenances required for this Project.

2. Review of submittals by the Manufacturer and the Contractor's Installer.

3. Scheduling and coordination of the required Work with the Manufacturer and the Contractor's Installer to complete the Project.

4. Oversees the installation of the geocomposite by the Contractor's Installer.

5. Inspections and reviewing testing results for compliance with the specified requirements.

6. Compiles the QA test results daily and documents the QA activities in weekly reports.

B. Manufacturer: The Manufacturer is the firm or corporation contracted by the Contractor for production of the geocomposite material used in the Project. The Manufacturer produces a consistent product meeting or exceeding the specifications and provides QC documentation for the product(s) specified herein.

C. Contractor's Installer: The Contractor's Installer is the firm or corporation contracted by the Contractor for installation of the geocomposite. The Contractor's Installer can be the Manufacturer or a Manufacturer-approved installer trained and certified to install the Manufacturer's geocomposite. The Contractor's Installer is responsible for field handling, storing, placing, seaming, sampling, testing, protecting and other aspects of the geocomposite installation.

D. Quality Control Laboratory: An independent Quality Control Laboratory (QCL) hired by the Contractor to perform compliance testing of the geocomposite material with demonstrated qualifications for conducting the required testing.

E. Construction Quality Assurance (CQA): CQA inspections are conducted by an independent third party specializing in geocomposite quality assurance/quality control (QA/QC). The CQA monitor collects samples and conducts independent QA testing.

F. Lot - A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geocomposite rolls. The finished rolls are identified by a roll number traceable to the resin lot.

1.6 QUALIFICATIONS

A. Manufacturer: Demonstrate the Manufacturer's ability to produce this geocomposite by having at least five (5) years continuous experience in the manufacturing of geocomposite and successfully manufactured a minimum of ten (10) million square feet of polyethylene geocomposite material for geocomposite installations.

B. Contractor's Installer: The Contractor's Installer can be the Manufacturer or a manufacturer-approved installer trained to install the Manufacturer's geocomposite. Perform installation under the constant direction of a single installation supervisor who remains on the Job Site and is in responsible charge through the geocomposite installation, seaming, patching, testing, repairs and other Job Site activities required by the Contractor's Installer.

1. Contractor's Installer has installed a minimum of 2,000,000 square feet of geocomposite in the last four (4) years.

2. Contractor's Installer has worked in a similar capacity on at least three (3) projects similar in complexity to the Project described in the Agreement, and with at least 400,000 square feet of geocomposite installation on each project.

3. The installation supervisor has worked in a similar capacity on projects similar in size and complexity to the Project described in the Agreement.

1.7 SUBMITTALS

A. General: Submit each item in this Technical Specification in accordance with the Conditions of the Agreement and Technical Specification 01 33 00 - Submittal Procedures.

B. Submittals relating to the geocomposite Manufacturer and the geocomposite material:

1. Manufacturing:

a. List of material properties of the geocomposite proposed for the Project meeting the requirements specified in this Technical Specification with attached certified test results.

b. Manufacturer's QC program and manual including description of in-house laboratory facilities.

c. A list of ten (10) completed projects totaling a minimum of ten (10) million square feet, for which the Manufacturer has manufactured the geocomposite specified to be used on this Project. Provide the following information for each project:

1) Name and purpose of project, the project location, and date of installation.

2) Name of the owner, project manager, design engineer, and installer.

3) Geocomposite type and surface area.

d. Qualifications statement in accordance with Paragraph 1.6 of this Technical Specification.

e. Manufacturer's recommendations for geocomposite installation procedures.

f. Prior to transporting any geocomposite to the Job Site, the Manufacturer submits the following documentation on the geocomposite to the Owner:

1) Copies of QC certificates issued by the raw material supplier including the production dates of the raw material and the origin of the raw materials used to manufacture the geocomposite for the Project.

2) Results of tests conducted by the Manufacturer to verify the resin quality used to manufacture the geocomposite rolls assigned to the Project and the resin origin, along with QC certificates issued by the resin supplier.

3) Certification that no post-consumer reclaimed polymer is added to the resin during the manufacture of the geocomposite to be used in this Project. Rework of identical manufactured product is allowable up to a limit of seven (7) percent by weight.

C. Submittals relating to the Contractor's installer:

1. Installation Capabilities:

a. Information on equipment and personnel.

b. Anticipated average daily production.

c. Number of crews employed and number available for this Work.

d. Qualifications statement in accordance with Paragraph 1.6 of this Technical Specification.

2. A list of five (5) completed projects totaling two (2) million square feet for which the Contractor's Installer has installed the geocomposite specified to be used on this Project. Provide the following information for each project:

a. Name and purpose of the project, the project location, and date of installation.

b. Name of the owner, design engineer, manufacturer, and name and telephone number of manufacturer's representative at the facility who can discuss the project.

c. Surface area of the installed geocomposite.

d. Type of seaming, patching and tacking equipment.

e. A copy of the manufacturer's certification or approval letter.

D. Within thirty (30) Business Days prior to geocomposite installation, submit the following:

1. Installation Quality Control:

a. A QC manual that specifically defines the QC program during installation for this Project. Include daily procedures, seaming techniques, specific steps that are to be taken in the event of a failure or defect, personnel requirements, levels of authority and other information necessary to ensure a high-quality geocomposite installation consistent with manufacturer recommendations and this Technical Specification in the manual.

b. Resume of the installation supervisor to be assigned to and on the Job Site during the Project.

c. A list of personnel performing installation and seaming operations along with pertinent experience information.

1.8 QUALITY CONTROL

A. In addition to Manufacturer and Contractor's Installer requirements for qualifications and certification specified in Paragraph 1.6 of this Technical Specification, QC consists

of compliance testing of the material prior to delivery to the Job Site and field QC during installation.

B. Manufacturer compliance testing requirements are specified in Paragraphs 2.3 and Paragraph 2.4 of this Technical Specification. The purpose of compliance testing is to verify that the supplied material complies to the requirements of this Technical Specification and to the Manufacturer's quality control certificates.

C. Geocomposite QC Documentation:

1. Project Files:

   a. Maintain two (2) duplicate Project files. One Project file is maintained by the Contractor and the other Project file is maintained by the Contractor's Installer. The Contractor's Installer provides the Contractor with complete daily documentation by the end of the following Business Day. At the end of each Work week, the Contractor and Contractor's Installer update and check the Project files to assure that copies of pertinent Project information are included in each file.

   b. Make blank copies of the Project forms available on the Job Site throughout the duration of the Project.

1.9 DELIVERY, STORAGE AND HANDLING

A. Package and ship the geocomposite rolls by appropriate means to prevent damage of the geocomposite rolls. Off-loading, handling, and storage of the geocomposite is the responsibility of the Contractor's Installer. The Contractor's Installer is responsible for replacing any damaged or unacceptable geocomposite material.

B. Roll Identification: The manufacturer provides geocomposite rolls marked or tagged with the following information:

1. Manufacturer's name.

2. Product identification.

3. Thickness.

4. Roll dimensions.

5. Manufacturer's roll and lot number.

6. Date of manufacture.

C. Damage during off-loading is documented by the Contractor. Damaged geocomposite rolls must be separated from the undamaged geocomposite rolls and be removed by the Manufacturer from the Job site.

D. Store the geocomposite rolls to be protected from puncture, dirt, grease, water, mud, mechanical abrasions and excessive heat or cold that can damage the geocomposite material. Store the geocomposite rolls on a prepared surface (not wooden pallets or hard abrasive surfaces) and do not stack more than two (2) rolls high.

PART 2 PRODUCTS

2.1 GENERAL

A. Final Cover Systems (CCR Impoundment Closure and Phase 1 Landfill Modification)

1. The geocomposite, used as the drainage layer of the final cover system, is a high capacity, double-sided geocomposite designed for final cover system applications.

   a. The geocomposite consists of a geonet with a double-sided non-woven needle punched polypropylene geotextile thermally bonded to each side of the geonet.

2. The required geocomposite has the property values shown in the attached Table 1. Provide results of tests performed using the procedures listed in the attached Table 1 from the geocomposite Manufacturer, as well as certification that the material meets or exceeds the specified values (refer to Paragraph 2.6 of this Technical specification).

B. Leachate Management System (Phase 1 Landfill Modification)

1. The geocomposite, used as the leachate collection layer of the bottom liner system, is a high capacity, double-sided geocomposite designed for leachate collection system applications.

   a. The geocomposite consists of a geonet with a hybrid geotextile consisting of a woven and non-woven needle punched geotextile with the two geotextiles bonded together mechanically as the filter surface and non-woven needle punched polypropylene geotextile as the friction surface thermally bonded to each side of the geonet.

2. The required geocomposite has the property values shown in the attached Table 2. Provide results of tests performed using the procedures listed in the attached Table 2 from the geocomposite Manufacturer, as well as certification that the material meets or exceeds the specified values (refer to Paragraph 2.6 of this Technical specification).

2.2 GEOTEXTILE

A. Manufacture the woven and non-woven needle punched geotextile specified in this Technical Specification from staple fiber.

B. Manufacture the geotextile from prime quality virgin polymer.

C. Furnish geotextile able to withstand direct exposure to ultraviolent radiation from the sun for up to 30 days without any noticeable effect on index or performance properties.

D. The geotextiles are thermally bonded to the geonet component of geocomposite rather than chemically bonded.

E. Along the edges, do not heat bond six (6) to 12 inches of the geotextile to allow adjacent geonet panel connection in the field.

2.3 GEONET PROPERTIES

A. Manufacture the geonet by extruding two crossing strands to form a bi-planar drainage net structure.

B. The geonet contains a maximum of one (1) percent by weight of additives, fillers, or extenders (not including carbon black) and does not contain foaming agents or voids within the ribs of the geonet.

C. Resin

1. Resin is new first quality, compounded polyethylene resin.

2. Natural resin (without carbon black) meets the additional minimum requirements provided in the attached Table 1 and Table 2.

2.4 GEOCOMPOSITE PROPERTIES

A. Manufacture the geocomposite with properties similar to the Geocomposite listed in the attached Table 1 and Table 2.

2.5 MANUFACTURING QUALITY CONTROL

A. Manufacture the geocomposite in accordance with the Manufacturer's QC Plan submitted to and approved by the Owner.

B. Geocomposite material in non-compliance with this Technical Specification is subject to rejection.

2.6 COMPLIANCE TESTING

A. Tests: Perform compliance testing by an independent QCL provided and paid for by the Contractor. Obtain the samples from the roll, mark the machine direction and identification number and ship the samples to the QCL by the Manufacturer. If appropriate arrangements are made with the Manufacturer, the QCL can go to the Manufacturer's facility and obtain the required samples. Performed the compliance tests for the geocomposite material properties listed in the attached Table 1 and Table 2 for the geonet and geotextile components of the geocomposite and the geocomposite.

B. Frequency: Perform the compliance tests in accordance with Table 1 and Table 2 and Paragraph 2.7(A) for interface strength at a frequency as shown unless otherwise noted or approved by the Owner.

C. Acceptance or Rejection: Prior to shipment of the geocomposite to the Job Site, the Contractor reviews the compliance test results for acceptance or rejection of the geocomposite material. Test results must meet, or exceed, the property values listed in Table 1 and Table 2 for acceptance of the geocomposite materials. The course of action implemented for retesting failing tests is approved by the Owner. In case of failing test results, the Manufacturer can request that another sample be retested by the independent laboratory with the Manufacturer's technical representative present during the testing procedures. The Manufacturer can also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results, the material is accepted. If both laboratories do not report passing results, the geocomposite material from the lot or bracketed square footage representing the failing sample is considered out of specification and rejected for use on this Project.

2.7 SITE-SPECIFIC REQUIREMENTS

A. Conduct interface friction (direct shear) and transmissivity testing using site-specific soils. The test methods and required results are as presented in the attached Table 3.

PART 3 EXECUTION

3.1 PRE-INSTALLATION

A. Prior to implementing the Work within this Technical Specification, the Contractor's Installer carefully inspects the installation area and verifies that all Work is complete to the point where the installation of the geocomposite can properly commence without adverse impact.

B. If the Contractor's Installer has any concerns regarding the conditions where the geocomposite is to be installed, the Contractor's Installer notifies the Owner in writing prior to initiating the Work of this Technical Specification. Failure to inform the Owner in writing is not construed as the Contractor's Installer's acceptance of the related Work of all other Technical Specifications.

3.2 SURFACE PREPARATION

A. Install the geocomposite on a surface which is dry and free of excessive dust, dirt, or stones. If excessive dust, dirt, or stones are present on the geomembrane, clean the geomembrane by sweeping or other acceptable method(s) to remove the excessive dust, dirt, or stones from the surface of the geomembrane.

3.3 MATERIAL PLACEMENT

A. General

1. Handle geocomposite materials/rolls, by the Contractor's Installer, in such a manner as to ensure the geocomposite is not damaged in any way. Install geocomposite, by the Contractor's Installer, in accordance with Manufacturer's recommendations.

    a. Remove all labels from the geocomposite roll and/or packaging and submit to the Owner by the Contractor's Installer.

2. Personnel working on the geocomposite do not smoke, wear damaging shoes, or engage in activities that can cause damage to the geocomposite and the underlying geomembrane.

3. Under no circumstance, drag equipment or other potentially damaging objects across exposed surfaces of the geocomposite.

4. Use a utility knife with a sharp blade to make all required cuts in the geocomposite. Change blades frequently to maintain suitable sharpness for cutting. Exercise care to prevent alteration or damage to any underlying material during cutting.

5. During placement, take care not to entrap dirt or excessive dust that could cause clogging of the drainage system and/or stones that could damage the material. If dirt, excessive dust, or stones are entrapped in the geocomposite, clean the geocomposite prior to placement of the overlying soil material.

6. Replace any geocomposite roll, panel, or portion which is damaged by stones or other objects, or installation activities by the Contractor's Installer.

7. Do not install the geocomposite during precipitation events and/or if the underlying geomembrane is wet.

8. Place on the geocomposite adequate temporary loading and/or anchoring (e.g., sand bags, tires, etc.) not likely to damage the geocomposite to prevent uplift by wind. Temporary loading and/or anchoring, used during placement, remains on the geocomposite until replaced with cover material.

9. Anchor the geocomposite as shown on the Project drawings.

B. Geocomposite Placement

1. Place the geocomposite parallel to the slope, unrolled from the top of the slope, and down the slope to the toe of the slope in the intended direction of flow, unless otherwise specified by the Owner.

    a. If the Project contains long, steep slopes, take special care such that only full length rolls are used at the top of the slope.

2. When the Project includes an anchor trench at the top of the slope(s), properly anchor the geocomposite to resist sliding. Do not allow the anchor trench compacting equipment to come into direct contact with the geocomposite.

3. Stagger horizontal seams and overlap such that the upgradient geocomposite is placed over the downgradient geocomposite.

    a. Shingle adjoining geocomposite rolls (end to end) across the roll width down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width.

4. Overlap at the seams all geotextile bonded to the geonet a minimum of 20-inches.

5. Overlap the material for butted panels a minimum of two (2) feet on slopes.

6. The minimum geonet overlap on seams is four (4) inches.

7. Eliminate wrinkles and “fishmouths” before sewing the top geotextile.

C. Geocomposite Seaming

1. Secure or seam each component of the geocomposite to the like component at overlaps.

2. Overlap the geonet in the machine direction three (3) to five (5) inches and six (6) to 12 inches in the traverse direction with overlaps joined by tying the geonet structure with cable ties. Space the cable ties every five (5) feet along the roll length.

3. Secure the geonet overlaps by tying using strings, plastic fasteners, or polymer braid. Use tying devices of any visible color other than black for easy observation. Metallic tying devices are not permitted.

4. Place tying devices every five (5) feet along the slope, every two (2) feet across the slope, every six (6) inches in the anchor trench, and every ten (10) feet on horizontal surfaces.

5. Just overlap the bottom geotextiles and continuously sew the top geotextiles (i.e., spot sewing is not allowed) only.

6. Use Polymeric thread for all sewing. Sew seams using Stitch Type 401 (i.e., double chain stitch). Use Federal Standard Type SSa-1 seam type (i.e., prayer-type seam); stapled or nailed seams are not allowed.

3.4 REPAIR

A. Prior to covering the deployed geocomposite, inspect each roll for damage resulting from installation.

B. Repair holes or tears in the geocomposite by closing or removing the damaged portion and placing a geocomposite patch over the damaged area.

1. Use the same geocomposite material as the geocomposite requiring the patch for the geocomposite patch.

2. Overlap the geocomposite patch on all edges of the damaged area by a minimum of six (6) inches.

3. Secure the geocomposite patch in place with ties for the geonet every six (6) inches around the circumference of the patch.

4. Continuously sew the top layer of the geotextile component around the circumference of the patch using polymeric thread and seam type presented in Subparagraph 3.3C(6).

C. Nailing or stapling geocomposite patch materials is not allowed.

D. Prior to installation of any geocomposite patch, the Contractor's Installer removes any soil or other material which potentially can adversely affect the bond between the geocomposite patch and the underlying geocomposite.

3.5 PROTECTIVE SOIL COVER PLACEMENT

A. The Contractor or the Contractor's Installer places the protective soil cover or gypsum materials in accordance with the methods and procedures discussed in Technical Specification 31 20 00 – Earth Moving.

B. Proceed with placement of the protective soil cover or gypsum following the placement and inspection of the geocomposite as soon as possible.

3.6 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus geocomposite and waste materials, including trash, and debris, and legally dispose of off the Owner's property.

END OF SECTION

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Table 1. Minimum Physical Properties of Final Cover System Geocomposite

Property	Units	Test Method	Value	Frequency
Geonet Component [a, b]				
Thickness	mil	ASTM D5199-12	300	Every 50,000 SF
Density	g/cm^3	ASTM D1505-10	0.94	Every 50,000 SF
Transmissivity [c, d]	m^2/sec	ASTM D4716/D4716M-14	8.0x10^{-3}	Every 200,000 SF
Tensile Strength (MD)	lb/in	ASTM D7179-07(2013)	75	Every 50,000 SF
Carbon Black Content	%	ASTM D4218-15	2-3 (range)	Every 50,000 SF
Geotextile Component [a, b]				
Mass per Unit Area	oz/yd^2	ASTM D5261-10	8	Every 100,000 SF
AOS, US Sieve	mm	ASTM D4751-16	80 (0.18)	Every 100,000 SF
Permittivity	sec^{-1}	ASTM D4491/D4491M-16	1.3	Every 100,000 SF
Flow Rate	gpm/ft^2	ASTM D4491/D4491M-16	95	Every 100,000 SF
Grab Tensile Strength	lbs	ASTM D4632/D4632M-15a	220	Every 100,000 SF
Grab Elongation	%	ASTM D4632/D4632M-15a	50	Every 100,000 SF
Trapezoidal Tear Strength	lbs	ASTM D4533/D4533M-15	90	Every 100,000 SF
CBR Puncture Strength	lbs	ASTM D6241-14	575	Every 100,000 SF
UV Resistance	% retained	ASTM D4355/D4355M-14	70	Per formulation
Geocomposite				
Ply Adhesion	lb/in	ASTM D7005/D7005M-16	1.0	Every 100,000 SF
Transmissivity [c, d]	m^2/sec	ASTM D4716/D4716M-14	9.0x10^{-4}	Every 200,000 SF
Resin				
Polymer Density	g/cm^3	ASTM D1505-10	>0.94	Once per Lot
Melt Flow Index	g/10 min	ASTM D1238-13	≤ 1.0	Once per Lot

Notes:

(a) Component properties prior to lamination.
(b) All values are minimum average roll values (MAV) except AOS which is maximum average roll value (MaxARV) and UV resistence is a typical value. Geonet core thickness is a nominal value.
(c) Gradient of 0.1 normal load of 10,000 pounds per square foot (psf), water at 70◦F between steel plates for 15 minutes.
(d) The geocomposite Manufacturer provides a recommended creep reduction factor to the Owner for use in evaluating the allowable transmissivity of the geocomposite. The recommended value is supported by product-specific testing data.

g/cm^3 – grams per cubic centimeter; MD – machine direction; lb/in – pounds per inch; % - percent; oz/yd^2 – ounces per square yard; mm – millimeters; sec^{-1} – seconds; gpm/ft^2 – gallons per minute per square foot; lbs – pounds; m^2/sec – square meters per second; ASTM - American Society for Testing and Materials

The above tests are performed by the Manufacturer of the geocomposite for identification of the Manufacturer's product.
Submit the test results to the Contractor for approval of the product. The geocomposite supplied for the Project meets these properties.

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Table 2. Minimum Physical Properties of Leachate Collection System Geocomposite

Property	Units	Test Method	Value	Frequency
Geonet Component [a, b]				
Thickness	mil	ASTM D5199-12	300	Every 50,000 SF
Density	g/cm^3	ASTM D1505-10	0.94	Every 50,000 SF
Tensile Strength (MD)	lb/in	ASTM D7179-07(2013)	75	Every 50,000 SF
Carbon Black Content	%	ASTM D4218-15	2-3 (range)	Every 50,000 SF
Compressive Strength	pcf	ASTM D6364-06(2011)	25,000	Every 50,000 SF
Top Geotextile Component [a, b]				
Structure	Hybrid monolithic woven-nonwoven needle punched			
Mass per Unit Area	oz/yd^2	ASTM D5261-10	14	Every 100,000 SF
AOS, US Sieve	mm	ASTM D4751-16	170 (0.09)	Every 100,000 SF
Permittivity	sec^{-1}	ASTM D4491/D4491M-16	0.3	Every 100,000 SF
Flow Rate	gpm/ft^2	ASTM D4491/D4491M-16	20	Every 100,000 SF
Grab Tensile Strength	lbs	ASTM D4632/D4632M-15a	200	Every 100,000 SF
Trapezoidal Tear Strength	lbs	ASTM D4533/D4533M-15	85	Every 100,000 SF
CBR Puncture Strength	lbs	ASTM D6241-14	775	Every 100,000 SF
UV Resistance	% retained	ASTM D4355/D4355M-14	70	Per formulation
Field Tests [e]				Per formulation
Bottom Geotextile Component [a, b]				
Mass per Unit Area	oz/yd^2	ASTM D5261-10	6	Every 100,000 SF
AOS, US Sieve	mm	ASTM D4751-16	70 (0.212)	Every 100,000 SF
Permittivity	sec^{-1}	ASTM D4491/D4491M-16	1.5	Every 100,000 SF
Flow Rate	gpm/ft^2	ASTM D4491/D4491M-16	110	Every 100,000 SF
Grab Tensile Strength	lbs	ASTM D4632/D4632M-15a	160	Every 100,000 SF
Grab Elongation	%	ASTM D4632/D4632M-15a	50	Every 100,000 SF
Trapezoidal Tear Strength	lbs	ASTM D4533/D4533M-15	65	Every 100,000 SF
CBR Puncture Strength	lbs	ASTM D6241-14	435	Every 100,000 SF
UV Resistance	% retained	ASTM D4355/D4355M-14	70	Per formulation

Table 2. (cont.) Minimum Physical Properties of Leachate Collection System Geocomposite

Geocomposite				
Ply Adhesion	lb/in	ASTM D7005/D7005M-16	0.5	Every 100,000 SF
Transmissivity (c, d)	m^2/sec	ASTM D4716/D4716M-14	$9.0x10^{-4}$	Every 200,000 SF
Resin				
Polymer Density	g/cm^3	ASTM D1505-10	>0.94	Once per Lot
Melt Flow Index	g/10 min	ASTM D1238-13	≤ 1.0	Once per Lot

Notes:

(a) Component properties prior to lamination.
(b) All values are minimum average roll values (MAV) except AOS which is maximum average roll value (MaxARV) and UV resistence is a typical value. Geonet core thickness is a nominal value.
(c) Gradient of 0.1 normal load of 10,000 pounds per square foot (psf), water at 70◦F between steel plates for 15 minutes.
(d) The geocomposite Manufacturer provides a recommended creep reduction factor to the Owner for use in evaluating the allowable transmissivity of the geocomposite. The recommended value is supported by product-specific testing data.
(e) Filter compatibility with a minimum of three (3) types of CCR materials (fly ash, stabilized FGD, and FGD gypsum) under simulated field conditions.

g/cm^3 – grams per cubic centimeter; MD – machine direction; lb/in – pounds per inch; % - percent; oz/yd^2 – ounces per square yard; mm – millimeters; sec^{-1} – seconds; gpm/ft^2 – gallons per minute per square foot; lbs – pounds; m^2/sec – square meters per second; ASTM - American Society for Testing and Materials

The above tests are performed by the Manufacturer of the geocomposite for identification of the Manufacturer's product.
Submit the test results to the Contractor for approval of the product. The geocomposite supplied for the Project meets these properties.

Table 3. Geocomposite Drainage Layer (GDL) - Site-Specfic Properties

Property	Units	Test Method	Value	Frequency[a]
Interface - GDL/Geomembrane[b][c]	degrees	ASTM D5321/D5321M-14	Peak = 26 degrees[e] Residual = 22.5 degrees[e]	One per interface
Interface - GDL/Cover Soil and Gypsum[b][c]	degrees	ASTM D5321/D5321M-14	Peak = 26 degrees[e] Residual = 22.5 degrees[e]	One per interface
Transmissivity[d]	m^2/sec	ASTM D4716/D4716M-14	See Table 1	One per interface

Notes:

(a) Site-specific testing is conducted at the frequency of 1 test/100,000 square feet unless otherwise noted.
(b) Perform interface tests at normal stresses of 1, 2, and 4 pounds per square inch (psi) with a displacement rate of 0.04 inches per minute (in/min), under wet conditions, report peak and residual values.
(c) The Contractor provides site-specific soils (borrow soil) and gypsum to the QCL along with the Manufacturer provided site-specific geocomposite.
(d) See Table 1 for transmissivity testing parameters.
(e) For cohesion/adhesion intercept = 0 pounds per square-foot (psf). Interface friction values less than those specified, but containing cohesion/adhesion are evaluated for acceptance by the Owner.

GDL – geocomposite drainage layer; ASTM - American Society for Testing and Materials; m^2/sec – square meters per second

The above tests are performed by the Manufacturer of the geocomposite for identification of the Manufacturer's product. Submit the test results to the Contractor for approval of the product. The geocomposite supplied for the Project meets these properties.

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PM Attachment 9 - Geotechnical Instrumentation

PM Attachment 9 - Geotechnical Instrumentation to Measure Pore-water Pressure and Settlement

Background

Amec Foster Wheeler's involvement at EW Brown began in 2008, during the second vertical expansion of the Main Ash Pond Dikes. Over the course of Amec Foster Wheeler's involvement, several explorations, including CPT soundings and installation of traditional piezometers were completed within the old ash pond limits. Additionally, a geotechnical exploration, to characterize the ponded CCR, was conducted in 2006, by others. CPT soundings, water dissipation results, geotechnical explorations, as well as our knowledge of groundwater measured in existing traditional piezometers surrounding the Main Ash Pond, was used to develop the depths and locations for the new geotechnical electronic monitoring devices.

Purpose

Amec Foster Wheeler installed monitoring devices at 9 locations in the Main Ash Pond in March 2014 to evaluate the presence of shallow and deep water-bearing strata and monitor pore-water pressure and settlement during construction of the proposed landfill.

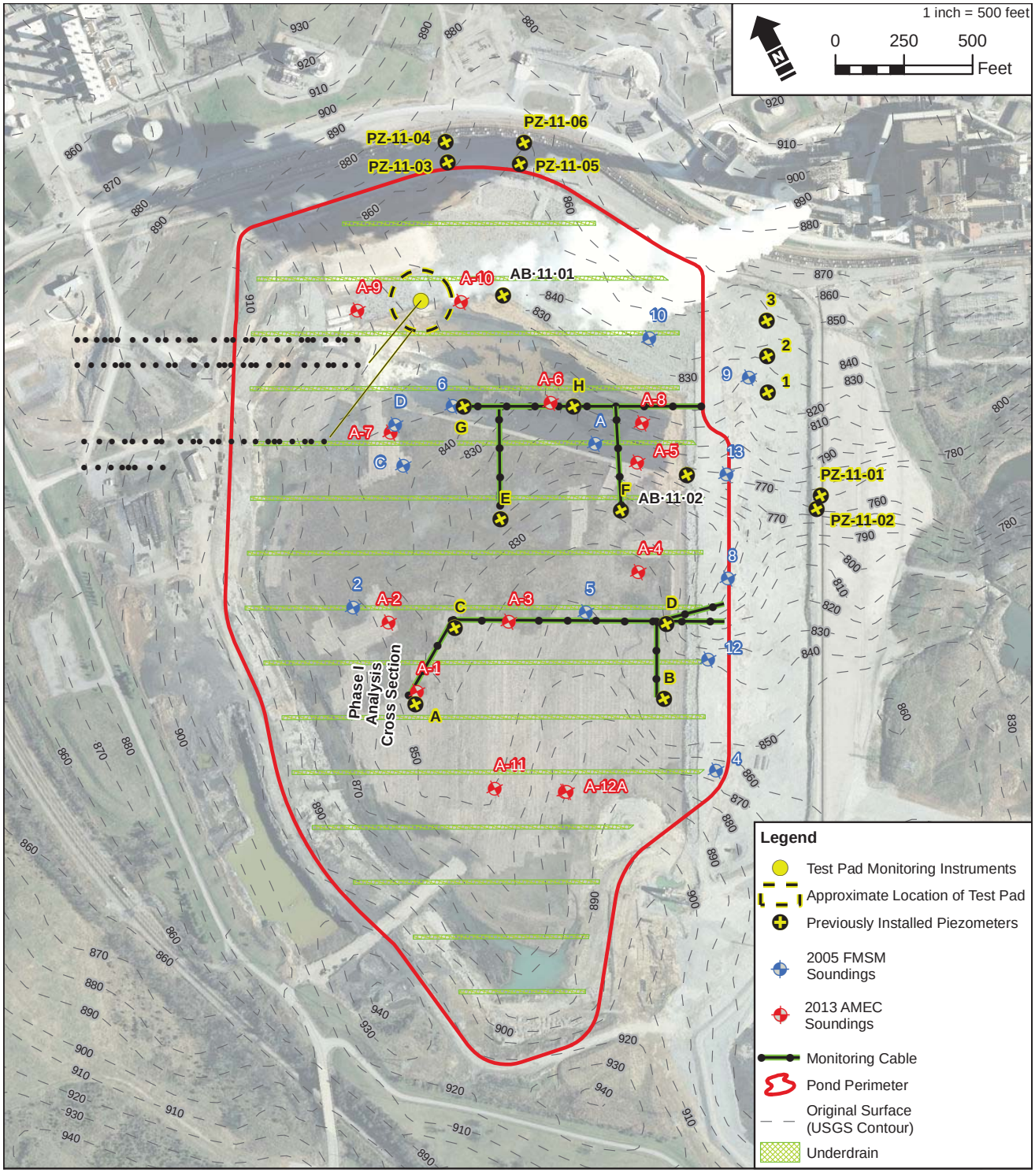
Location

The nine monitoring locations are shown on Figure 1. Locations labeled "A" through "D", were installed in Phase 1 (cell 1) of the landfill, locations "E" through "H" were installed in Phase 1 (cell 2), and location "J", was installed in Phase 3, in the area recognized as the "Test Pad".

Description

The monitoring device type, installation, and data collection are consistent with established industry standards, for the most technologically advanced instruments available, at the time of installation. The operating principals and instrument specifications were described in Volume 6, Appendix 28-V, *"Landfill Piezometer Installation and Settlement Monitoring Program,"* found in the Landfill Application.

The monitoring devices installed at Locations A, B, C and D (see Figure 1) are actively collecting water level and settlement data. Device J, was active during temporary placement of gypsum for the Test Pad. The piezometers and settlement systems at installed at Locations E, F, G, H, and J are currently inactive, because there is no construction activity or CCR placement in this area. All monitoring devices were designed to be active during construction and active landfilling activity.



LG&E Kentucky Utilities	LG&E KU PPL companies	MAP BY: daniel.conn CHK'D BY: AS	EW Brown Landfill Harrodsburg, KY 40330	TIME: 12:45:41 PM DATE: 3/18/2016
Amec Foster Wheeler Environment & Infrastructure 690 Commonwealth Center 11003 Bluegrass Parkway Louisville, KY 40299	amec foster wheeler	PROJECTION: NAD 1983 StatePlane Kentucky SCALE: 1 inch = 500 feet	Landfill Monitoring Device Locations	PROJECT #: 567530038 Figure #: 1

LocationPlan

Imagery: KY APED 2012

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 3

Witness: Stuart A. Wilson

Q-3. Refer to the Direct Testimony of Robert M. Conroy ("Conroy Testimony"), page 7. Provide the CCR projections originally used for Project 36, and the current forecast for CCR production by generating unit for the projected remaining life of coal fired generation at Brown.

A-3. See the following table based on the Mid Gas-Coal spread scenario. The original analysis evaluated the Brown station's CCR production through 2021. The current analysis reflects the planned retirement of Brown 1 and 2 in February 2019 and the impact of the one-year rail transportation agreement with Norfolk-Southern railroad for 2018, which lowers Brown's variable fuel cost in 2018.

Brown CCR Production (Thousand Cubic Yards, Mid Gas-Coal Spread)

Year	Brown 1		Brown 2		Brown 3		Brown Total	
	Original	Current	Original	Current	Original	Current	Original	Current
2016	18		36		89		143	
2017	21		36		97		154	
2018	22	31	36	54	110	112	169	197
2019	22	5	44	8	114	101	180	114
2020	23	0	44	0	96	74	162	74
2021	28	0	49	0	116	100	193	100
2022		0		0		91		91
2023		0		0		96		96
2024		0		0		93		93
2025		0		0		107		107
2026		0		0		97		97
2027		0		0		95		95
2028		0		0		104		104
2029		0		0		105		105
2030		0		0		103		103
2031		0		0		114		114
2032		0		0		103		103
2033		0		0		109		109
2034		0		0		89		89
2035		0		0		116		116

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 4

Witness: Robert M. Conroy / Christopher M. Garrett

Q-4. Refer to the Conroy Testimony, page 10.

a. Explain why KU is proposing an amortization period that aligns with Project 39 instead of Projects 40-42.

b. Explain the issues and concerns that a third amortization period would create for KU.

c. Provide the impact on ratepayers if a ten- or twenty-five year amortization period were to be authorized versus an eight-year amortization period. Provide any calculations in Excel spreadsheet format with formulas intact and unprotected and all rows and columns accessible.

A-4. a. KU believes it is more appropriate to align with the retired stations' amortization period given the requirement to close the ash pond was partially the result of the decision to retire Brown Units 1 and 2. Additionally, the probable retirement years utilized in the most recent depreciation study for Brown 1, Brown 2 and Brown 3 were 2023, 2029 and 2035, respectively indicating a life much shorter than the remaining 23 year amortization period for the active stations. Given these two factors, in addition to accounting efficiencies gained from utilizing an established amortization period, KU has proposed to use the shorter retired station amortization period.

b. Because KU is regulated in multiple jurisdictions[1], the accounting for CCR costs is complex given different amortization periods and methodologies. Therefore, adding an additional amortization period further exacerbates this issue.

c. See the attachments provided in Excel format.

[1] Kentucky Public Service Commission, Federal Energy Regulatory Commission and Virginia State Corporation Commission.

Two Attachments in Excel

The attachment(s) provided in separate file(s) in Excel format.

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 5

Witness: Robert M. Conroy

Q-5. Refer to Exhibit RMC-3, pages 2 and 4 of 4. Explain why operating expenses include additions for lines labeled "Less depreciation on retired plant" and "Less amortization on retired plant" respectively (emphasis added).

A-5. On Exhibit RMC-3, pages 2 and 4 of 4, the lines labeled "Less depreciation on retired plant" and "Less amortization on retired plant" were mislabeled and should be labeled "Amortization on retired plant".

Exhibit RMC-3 was prepared consistent with the calculation of the revenue requirement in the ECR monthly filings where Pollution Control Operating Expenses ("OE") include all costs of operating and maintaining environmental facilities, income taxes, property taxes, and depreciation and amortization expenses. The referenced lines shown with "Operating expenses" on Exhibit RMC-3 are included to provide the Commission with the level of detail included in the ECR monthly filings.

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 6

Witness: R. Scott Straight / Stuart A. Wilson

Q-6. Refer to the Direct Testimony of R. Scott Straight ("Straight Testimony"), page 4.

a. Explain whether the CCR material that was placed in the Auxiliary CCR Impoundment due to the delay in receiving the operating permit remains in the impoundment.

b. Provide the total capacity of the Auxiliary CCR Impoundment, the current amount of CCR material in the impoundment, and the estimated date KU will reach the capacity of the impoundment.

c. State whether it is still KU's intent to close the Auxiliary CCR Impoundment by the end of 2023.

A-6. a. All CCR material that has been placed into the Auxiliary CCR Impoundment will remain in the impoundment and supports the closure of the impoundment.

b. The design capacity of the Auxiliary CCR Impoundment is approximately 1.9 million cubic yards. The current amount of CCR stored in the impoundment is 1.6 million cubic yards. Upon starting closure activities in the first half of 2019, the expected volume of CCR stored in the Auxiliary CCR Impoundment will be 1.7 million cubic yards. Therefore, it will be closed before reaching the design capacity.

c. Yes. Closure is anticipated to start the first half of 2019 and be completed by mid-2021.

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 7

Witness: R. Scott Straight

Q-7. Refer to the Straight Testimony, page 5. Confirm that the estimated 2.5 million cubic yards storage capacity in the Brown CCR landfill represents the total CCR storage for the landfill, and not the storage capacity requirement for the remaining life of coal-fired generation at Brown.

A-7. Yes, 2.5 million cubic yards is the reduced design capacity of the landfill. As discussed in Mr. Wilson's testimony on pages 4-5, including the current capacity of Phase I, and assuming the possibility of retiring Brown 3 after 55 years of life, Brown will need between 0.8 million and 2.7 million cubic yards of dry CCR storage capacity.

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 8

Witness: R. Scott Straight

Q-8. Refer to the Straight Testimony, page 6. Describe the cap-and-closure process proposed in Amended Project 36, and how it differs from the original plan.

A-8. The original Brown landfill project was designed to be constructed in three phases and serve as the entire cap for the Main Ash Pond once Phase III was constructed and placed into operation. The landfill liner provided a dual function as the leachate liner for the entire landfill as well as the cap and closure liner for the Main Ash Pond. Because the amended landfill project does not encompass the entire footprint of the Main Ash Pond, the remaining area of the Main Ash pond will be capped and closed using the same liner system that underlies the landfill. The liner system consists of clay subgrade graded to promote drainage, geotextile, Geosynthetic Clay Liner (GCL), Flexible Membrane Liner (FML), geocomposite drainage layer, 18 inches of soil, and 6 inches of topsoil. See the attachment included in response to Question No. 1 for a cross section of the cap and closure liner system.

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 9

Witness: Gary H. Revlett

Q-9. Refer to the Direct Testimony of Gary H. Revlett, page 3. Confirm that the draft proposal for amendments to the Disposal of Coal Combustion Residuals from Electric Utilities final rule signed March 1, 2018, is not expected to impact the timing or design requirements of Amended Project 36.

A-9. EPA's draft CCR proposal for amendments will not have any impact on the planned design or timing of Amended Project 36.

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 10

Witness: Stuart A. Wilson

Q-10. Refer to the Direct Testimony of Stuart A. Wilson ('Wilson Testimony"), page 3. Provide the time frame necessary to produce 130 thousand cubic yards of CCR material.

A-10. The current storage capacity for Phase I is 540 thousand cubic yards and its remaining storage capacity is 130 thousand cubic yards. CCR production at Brown can vary significantly in the short-term due to weather, the availability of other generating units, offsite beneficial use levels, and – to a lesser extent – fuel prices. Due to the variability in these factors, the station could produce 130 thousand cubic yards of CCR as early as July 2018. When considering the placement of CCR in the Brown Auxiliary Pond and the use of CCR to construct Phase II, Phase I's remaining 130 thousand cubic yards of storage capacity could be depleted as early as December 2018.

KENTUCKY UTILITIES COMPANY

Response to Commission Staff's First Request for Information Dated March 8, 2018

Case No. 2017-00483

Question No. 11

Witness: R. Scott Straight / Stuart A. Wilson

Q-11. Refer to the Stuart Testimony, page 4.

a. Explain the beneficial use of 100 thousand cubic yards of CCR material used to close the Auxiliary Pond and to construct Phase II.

b. Provide the status of the beneficial reuse agreement.

A-11.

a. Approximately 100 thousand cubic yards of CCR material will be placed in the Auxiliary CCR Impoundment rather than in Phase I of the landfill prior to starting closure of the impoundment.

An additional 100 thousand cubic yards of CCR material will be used as protective cover over top of the liner and leachate collection system for Phase II of the landfill.

b. KU has signed an agreement that gives a fly ash marketer the option to market Brown 3's fly ash for offsite beneficial use, but this option has not been exercised to date.