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COVER SYSTEM PLAN - FIGURE 5.1

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LETTER OF TRANSMITTAL

TO:	U.S. Environmental Protection Agency - Region V 77 W. Jackson Boulevard Chicago, IL 60604-3590	FROM:	Gary M. Wantland, P.E. 7650 W. Courtney Campbell Causeway Tampa, FL 33607-1462	DATE:	July 9, 2001
				Attention:	Michael McAteer
				JOB No.:	C100004221.00

RE: Response to Comments: Sauget Area I TSCA Containment Cell

The following items are being sent: ☒ Attached ☐ Under separate cover by

☐ Shop Drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications ☐ Copy of Letter

☐ Other

Copies	Date or Number	Description
1	July 9, 2001	Response to Comments: Sauget Area I TSCA Containment Cell Design Report Solutia Inc. - Cahokia, Illinois

Transmittals for reasons checked:

☐ For Your Approval ☐ No Exceptions Taken ☐ Resubmit ______ copies for approval

☒ For Your Use ☐ Make Corrections Noted ☐ Submit ______ copies for distribution

☐ As Requested ☐ Amend and Resubmit ☐ Return______ corrected prints

☐ For Review and Comment ☐

Remarks: Enclosed is a copy of the final comments to questions generated by Robert Watson (IEPA) based on his review of the Sauget Area 1 TSCA Containment Cell Design Report submitted on April 2, 2001. If you have any questions, please call.

Copies: Mike Light - Solutia Inc,
Bruce Yare, P.E. - Solutia Inc.

If enclosures are not as noted, kindly notify us at once.

Gary M Wantland

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RESPONSE TO COMMENTS SAUGET AREA 1 TSCA CONTAINMENT CELL DESIGN REPORT SOLUTIA INC. CAHOKIA, ILLINOIS

Prepared for:

Solutia Inc.
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Prepared by:

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C100004221.00

July 9, 2001

1630200005 - St. Clair County
Sauget Area 1, Dead Creek
Sediment Containment Cell
Superfund/Technical File

Reviewer: Rob Watson
Review Dates: May 7, 2001

Additional Response to Comments Part II
Sauget Area 1 TSCA Containment Cell Design Report
Time Critical Removal Work Plan, Dead Creek Sediment and Soil in Sauget and Cahokia

Introduction

The following comments are on the Sauget Area 1 TSCA Containment Cell Design Report submitted by Solutia on April 2, 2001.

Format of Comments

These comments follow the format of Solutia's responses to comments. Those comments that were not adequately addressed are indicated below together with several additional comments identified during the review of this document.

PART II COMMENTS

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
2.	Section 2 of the Design Report should include wording that indicates a groundwater monitoring plan for the TSCA containment cell is being reviewed concurrently with the construction of the containment cell.	The following wording was added to Section 2 of the Design Report on page 2-3; "A groundwater monitoring plan for the TSCA containment cell is being reviewed concurrently with the construction of the containment cell." The revised Section 2 is included as Attachment 1.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
10.	The response to Comment 10 states Section 5.0 will be revised to include a paragraph that indicates the sediments placed against the side slopes will be screened to remove sharp objects and other materials larger than 2 inches. First, it appears that Section 4 is a more appropriate location for this wording. However, I could not locate the referenced paragraph in either Section 4 or 5. Second, although the wording in Section 3.3.F in Specification 02225 was revised to address this issue, it does not specifically state that the 2 foot buffer layer of screened sediments will extend up the entire length of the side slope. The wording in Specification 02225 should be revised to more closely resemble the paragraph in the response to Comment 10.	As the response to Comment 10 indicated the proposed wording changes to the TCRAWP was to be added to Section 5.0, Sediment Handling, Treatment and Dewatering Plan of the TCRA Work Plan, not Section 5 of the Landfill Design Report. The Design Report was Appendix 7 of the TCRA Work Plan. However, as requested the wording in our response to Comment 10 will be added to the eleventh paragraph of Section 4.1.1. This paragraph will read as follows: "Leachate collection on the cell's side slopes will be provided by a geonet/ geotextile drainage composite to prevent soil clogging. The hydraulic transmissivity of geonet is at least 5 cm/sec. The wastes placed in the containment cell will directly contact the drainage composite on the side slopes. <u>To insure that the side-slope liner system is not punctured, excavated sediment in contact with the cell side slopes will be screened to remove material larger than 2 inches including sticks, trash and other sharp objects. While spreading sediments in the bottom of the cell, a bank of screened sediment will be placed two to three feet high and two to four feet thick at the toe of the slope. This bank of screened sediment will protect the side-slope liner system. When the fill reaches the height of this bank, another one will be constructed of screened sediment at the toe of the slope to protect the side-slope liner system</u>." The revised Section 4 is included as Attachment 2.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
		Technical Specification Section 02225 was also revised to include the suggested wording. Paragraph 3.3.F was changed as follows; "F. Place screened sediment on the side slope lining to a height of two to three feet above the toe of the slope and to a thickness of two to four feet. Screen these sediments to remove materials two inches and larger including sticks, trash, and other sharp objects. The minimum undrained shear strength requirement shall not apply to sediments placed in this zone. Side slope screened material will be extended to the crest of the landfill, in segments, of two to three feet in length." The revised specification is included as Attachment 3.
33.	The following comments pertain to the leachate detection system:	
a	The paragraph describing the high-level alarm system for the leachate detection system should be moved from the end of Section 4.5.4 to Section 4.5.1.	The last paragraph of Section 4.5.4 has been moved to Section 4.5.1. This is now the ninth paragraph of that section. The revised Section 4 is included as Attachment 2.
b	Section 4.5.1 needs to discuss the sizing of the leachate detection sump.	The sizing of the leachate detection sump has been added to the 8th paragraph of Section 4.5.1. This paragraph has been changed to read as follows; "The leak detection system will mirror the grading in the leachate collection system. The leak detection layer will include a 20-foot by 20-foot triangular shaped collection sump. The detection system elevation will

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
b	Section 4.5.1 needs to discuss the sizing of the leachate detection sump.	drop an additional 12 inches to accommodate the gravel sump. The remainder of the leak detection system will consist of a geonet drainage composite. A geotextile filter will be placed over the geonet where the soil layer between the primary and secondary lining systems is located. No geotextile will be placed over the geonet on the side slopes where the primary and secondary linings directly sandwich the geonet. A perforated HDPE pipe will extend from the gravel sump to the top of the completed cover system for periodic leachate removal. A flush-mounted vault will protect the pipe at ground surface. Figures 4-12 and 4-13 present the outlet pipe for the detection layer." The revised Section 4 is included as Attachment 2.
c	Figure 4-9 needs to be revised to include the leachate detection sump.	Figure 4-9 is intended to represent the gravel drain in the primary collection system. The plan view where this detail section was obtained does not intersect the leachate detection sump.
d	It appears that the portion of response to Comment 33 (originally provided in the November 3, 2000 submittal) that pertains to maximum leachate head and Section 4.5.4 is more appropriate for Comment 37 than it is for Comment 33.	No action required.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
36.	The narrative in Section 4.5.3 needs to indicate that the design of the leachate collection system consists of 18 inches of sand on top of a geotextile/geonet. In addition, the narrative needs to indicate which calculations in Appendix C demonstrate the leachate head on the primary liner system will not exceed 12 inches.	The first paragraph of Section 4.5.3 has been modified to include the following; "The primary leachate collection system consists of 18 inches of sand overlying a geotextile and geonet layer. The bottom lining for the leachate collection system will slope at…." In that same paragraph the following was added to the existing fourth sentence; "As demonstrated in the HELP Evaluation calculations presented in Appendix C, based on conservative assumptions of inflow rate,….." A revised Section 4 is included as Attachment 2.
37.	The HELP model for the closed landfill does not include the geotextile/geonet layer portion of the revised leachate collection system.	The HELP calculations for the closed landfill case have been revised to include the revised primary leachate collection system, which consists of 18 inches of sand overlying a geotextile and geonet layer. The figure included for the closed condition calculation was also modified to reflect that change. A revised figure and calculation is included as Attachment 4 in this submittal.
55.	Specifically, which geosynthetic products from which manufacturers will be used in the construction of the containment cell?	Although this information will be included in the record of construction report, since construction is underway, it is possible to relay this information. At this time the geosynthetic products that will be used in the construction of the disposal cell are as follows:

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
		• Geomembrane Textured Serrott HS601 / HT601 60 mil HDPE Smooth Serrott HD600 60 mil HDPE • Geonet Serrott Poly Net PN 3000 • Geotextile Synthetic Industries Geotex 16 oz/yd nonwoven geotextile • Geosynthetic Clay Liner Bentofix NSL "Reinforced" GCL Bentofix EC "Non-Reinforced" GCL If necessary, similar geosynthetic products from other manufacturers, will be substituted for the above. Required substitutions, if any, will be documented in the record of construction report.
66.	Section 2.4.4 of the CQA Manual for Geosynthetic Components (Appendix F) needs to be revised to indicate that the geomembrane is deployed as indicated in Section 3.4 of Specification 02244. That is, on the side slopes, the rolls of geomembrane should be deployed down slope in a controlled manner. Rolls of geomembrane should not be pulled up a side slope.	Section 2.4.4 of the CQA Manual for Geosynthetic Components shall be modified to add the requested wording. Item 5 of the that section will be changed to read as follows; 5. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil. <u>Rolls of geomembrane shall be deployed down a side slope in a controlled manner. Geomembrane shall not be pulled up the side slope</u>. A revised Section 2 of the Geosynthetic CQA manual is included as Attachment 5.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
66.	Section 6.4 of the CQA Manual for Geosynthetic Components (Appendix F) indicates GCL panels only need to be overlapped 4 inches. This is not acceptable. This section of the CQA Manual needs to be revised to indicate that GCL panels must be overlapped a minimum of 6 inches as indicated in Section 3.3 of Specification 02246.	Section 6.4 of the CQA Manual for Geosynthetic Components will be modified to indicate that a 6 inch overlap between panels is required. Item 1 of the section will be changed to read as follows; 1. Adjacent rolls shall be overlapped by at least 6 inches (150 mm). A revised Section 6 of the Geosynthetic CQA Manual is included as Attachment 6.

66. and 70.	Section 6 of the CQA Manual for Geosynthetic Components (Appendix F) needs to include wording that requires the CQA Officer to look for the following items: a. Rolls of GCL should not be stored on the ground prior to installation. b. All GCL deployed in a given day must be covered with either a geomembrane or 12 inches of approved soil cover.	Section 6.3 of the CQA Manual for Geosynthetic Components will be modified to incorporate the requested observations during installation of GCL materials. The first paragraph of this section will be changed to read as follows; "The Geosynthetic CQA Consultant shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Construction Manager. The Geosynthetic CQA Consultant shall verify that rolls of GCL are not stored on the ground prior to installation." Item 7 will be added to this section as follows; 7. All GCL deployed in a given day must be covered with either a geomembrane or 12 inches of approved soil cover.

		A revised Section 6 of the Geosynthetic CQA Manual is included as Attachment 6.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
78.	Section 4.2.4 of the CQA Manual for Soil Components (Appendix G) states that borrow soils that are lower than the TACO Tier 1 criteria for industrial/commercial area soils can be used for construction of the containment cell. This is acceptable so long as the notice in the deed for the closed landfill (see RCRA closure / post-closure requirements) clearly states that contaminated materials were used for the construction of the containment cell. This additional wording in the notice in the deed for the site would not be required if the borrow soils are at or below the TACO Tier 1 criteria for residential soils.	No action required.
84.	The following comments are related to Comment 84:	
a	The calculations for Q_{max} in Appendix D (the first set of calculations under Cover System Stormwater Control) are not legible. A darker copy of these calculations needs to be provided.	A clearer set of calculations are provided to replace the previous unreadable version. Please remove all of Appendix D and insert the attached replacement set. The replacement set is included as Attachment 7.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
b	It was my understanding that the downchute along the north berm was to be grass with riprap. Figures 5-1 and 5-6 seem to confirm this conclusion. However, the calculations for a concrete downchute are still in Appendix D. Calculations demonstrating that the grass/riprap design can accommodate the flow from a 25-year, 24-hour storm event, and not be subject to excessive erosion, need to be provided in Appendix D. If a concrete downchute will be used, Figures 5-1 and 5-6 need to be revised to show the concrete downchute.	The down chute included in the draft version of the design report has been replaced with two drop structures and HDPE piping to transport stormwater to a grassed lined outlet channel that discharges to Dead Creek. Please remove the existing Appendix D from your report and replace it with the attached (Attachment 7).
c	A detail drawing (like Figure 5-8) of the downchute outlet, and its relationship to Dead Creek needs to be provided. Figure 5-8 is titled "Downchute Outlet Detail," but it is actually the downchute inlet.	The figures in Section 5 were revised to provide the requested details. Figure 5-1 was modified to clarify how the details shown in Figures 5-6 through 5-10 relate to the plan view. Existing Figure 5-8 was renumbered to Figure 5-9. Figures 5-8 and 5-10 were added to provide the detail requested. Please remove Figures 5-1 and 5-8 and inset the attached Figures 5-1, 5-8, 5-9, 5-10. In addition, Section 5 was revised to identify the new figures and to clarify the design of the cover system. Please remove the Section 5 text and replace it with the attached. These items are included as Attachment 8 to this response.
d	The responses to Comment 84 in Part II (Item 89) and Part II, Group II (Item 118) need to be revised since they still do not address each portion of the comment individually.	Please see the information provided below.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
84. Part II (Item 89) and Part II, Group II (Item 118)	Run-Off Control Systems, Section 5.5: The design of the landfill needs to include a run-off control system that is capable of holding the stormwater from a 25-year, 24-hour storm after the unit is closed. It is not acceptable to discharge the run-off from the closed landfill directly to Dead Creek. A run-off control system for the closed landfill will prevent sediments from washing off the landfill and into the restored Dead Creek. Also, if the cover system fails, and the run-off becomes contaminated, the run-off control system will prevent the contaminated run-off, sediments and wastes, from entering and contaminating the restored Dead Creek. The description of the run-off control system needs to include the following:	During construction, stormwater in the cell will be pumped from the cell and discharged to Dead Creek. After sediment transfer, stormwater in the cell will be treated, as required, and discharged to the POTW. Once the cover is installed, sedimentation will be controlled using best management practices. After vegetation is established, there is no need to control runoff from the cell. Stormwater runoff will be routed to a drainage swale on the north side of the cell that discharges to Dead Creek. Design drawings for this swale, which is designed to handle a 25-year, 24-hour storm, are included as Figures 5-1 and 5-6 of the Design Report.
a	Design and Performance Describe the run-off collection and control system design. Provide calculations demonstrating that the system has sufficient capacity to collect and hold the total run-off volume. Provide a plan view showing the locations of the run-off control system components, along with sufficient drawing details and cross sections. Indicate the fate of the collected run-off.	Section 5.4 describes the cover design and Section 5.5 describes the Run-Off Control Systems. The calculations demonstrating the performance of the final cover system are described in Section 5.5 and included in Appendix D. Figure 5-1 presents the requested plan view of the cell. Details of the stormwater management system are presented in Figures 5-5, 5-6, 5-8, 5-9, and 5-10. The fate of the collected run-off is described in Section 5.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
b	Calculation of Peak Flow: Identify the total run-off volume expected to result from at least a 24-hour, 25-year storm. Describe data sources and methods used to make the peak flow calculation. Provide copies of the calculation. Provide copies of the calculations and data, including appropriate references.	Details of the calculations used to calculate peak flow are presented in Appendix D and in Section 5.5.
c	Management of Collection and Holding Units: Describe how collection and holding facilities associated with run-on and run-off control systems will be emptied or otherwise managed expeditiously after storms to maintain system design capacity. Describe the fate of liquids discharged from these systems.	Management and fate of stormwater run-off is presented in Section 5.5
d	Construction: Provide detailed construction and material specifications for the run-off control systems. Include descriptions of the construction quality control program that will be utilized to assure that construction is in accordance with design requirements.	Construction of the cover system is addressed in Section 6. In addition, the Specifications included in Appendix E, and the Construction Quality Assurance Plans in Appendices F and G address the construction requirements.
e	Maintenance: Describe any maintenance activities required to assure continued proper operation of the run-off control systems throughout the active life of the unit.	Maintenance issues are addressed in Section 5.5 and in Section 6.4

PART II, GROUP II COMMENTS

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
11.	In the October 10, 2000 meeting and the January 15, 2001 response to comments Part II, Group II, Solutia agreed, that to the extent practicable, the more highly contaminated material (e.g. Segment B sediments) would be placed more to the middle of the fill, not near the bottom or sides in an effort to better protect the soils and groundwater outside of the landfill. The narrative in the Design Report (Section 4) and Specification 02225 need to be revised to include this provision.	While we agree this item was discussed with IEPA at our October 10, 2000 meeting, it is our understanding that Solutia did not agree to this requirement. In the January 15, 2001 response to comments (Part II), Solutia indicated "that to the extent practicable material would be placed into the cell to prevent damage to the liner system which may include placing certain materials within the center." Due to site specific limitations and the required sequence of sediment removal, it is not practical to segregate the sediments and place them in a specific location within the containment cell based on levels of contamination. Solutia has agreed to screen the sediments prior to placement in the cell to remove material larger than 2 inches and items that may puncture the geomembrane or liner system materials. In addition, design of the double-lined containment cell, as well as the quality assurance program being implemented to ensure proper construction, are in accordance with current acceptable standards of practice (to IEPA and EPA) for management of potentially contaminated materials. It is Solutia's opinion the above measures agreed to for containment of collected sediments are appropriate, relevant and sufficient to provide the desired level of protection to surrounding soils and groundwater.
32.	It would be helpful if Section 4.5.1 included a brief description of the design and location of the warning light(s) for the leachate high-level alarms. Specifically, it is recommended that	Details of the location of the warning lights for the leachate collection systems will be presented in the Operation and Maintenance plan currently under development by Solutia.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
	each system have its own warning light. These lights should be within the security fence, but still readily visible to an inspector as they approach the site. For example, if they were located near the construction trailers, an inspector could determine if there was an alarm (high leachate level) without having to gain access to the site.	
57.	Solutia's response to this comment in the January 15, 2001 correspondence states that the GCL calculations (GCL Loading and Liner System Stability) will be modified to include consideration of the internal friction angle of the GCL material. The GCL calculations in the April 2, 2001 Design Report submittal do not include the internal friction angle of the GCL material. I could not locate GCL calculations for loading or slope stability subsequent to January 15, 2001 that address this comment.	Calculations including consideration of the internal friction angle of the GCL material are included with this submittal as Attachment 9. Please insert these into Appendix C of the Design Report.
61.	The Table of Geonet Properties in Specification 02246, and Table 1 in Appendix F, indicates the minimum value for transmissivity is 1cm/sec. These portions of the document (and Section 4.1.1) need to be revised to reflect the transmissivity value indicated in the calculations in Appendix C. The units (cm/sec) also need to be corrected to cm^2/sec or m^2/sec.	The calculations in Appendix C were generated to verify equivalent performance of the geonet to 12 inches of sand. As indicated the transmissivity of 12 inches of sand with a permeability of 1x 10^{-2} cm/sec is 0.305 cm^2/sec. A minimum geonet transmissivity of 1 cm^2/sec exceeds that value and therefore also demonstrates equivalent performance. As such no change is required to the minimum value as stated in the design specifications or CQA manual.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
		The referenced table in Specification 02246 and Table 1 in the CQA Manual for Geosynthetic Components will be revised to reflect the correct transmissivity units of cm^2/sec. A revised Table 1 for the Geosynthetic CQA manual is included in Attachment 10. A revised Specification 02246 is included as Attachment 11.
64.and 65.	The response to this comment states the narrative will be revised and references Section 3.3 (of Specification 02246). It does not appear that the narrative to the Design Report (Section 3.3 or elsewhere) was revised. The main question remains, is the CQA Consultant required to collect quality control samples, or just observe the sampling done by the contractor? In either case, Section 1.3.5.1 of Appendix F and Section 2.3.4.1 of Appendix G need to be revised to clarify this duty. Wording in the Specifications in Appendix E may also need to be revised if the CQA Consultant is responsible for sample collection.	The CQA Geosynthetic Consultant is responsible for collecting the conformance samples. The Technical Specifications will be changed to clarify this requirement. Section 3.4.C.2 of Specification 02242 Geotextiles will be changed as follows; "2. The Geosynthetic CQA Consultant will obtain samples and forward them to a laboratory designated by the Construction Manager." A revised Specification 02242 is included as Attachment 12. Section 3.6.C.2 of Specification 02244 Geomembranes will be changed as follows; "2. The Geosynthetic CQA Consultant will obtain samples and forward them to a laboratory designated by the Construction Manager."

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
		A revised Specification 02244 is included as Attachment 13. Section 3.3.C.2 of Specification 02246 Geonets will be changed as follows; "2. The Geosynthetic CQA Consultant will obtain samples and forward them to a laboratory designated by the Construction Manager." A revised Specification 02246 is included as Attachment 11.
68.	The minimum internal friction angles for both types of GCLs are not included in Table 1 in Appendix F.	Table 1 in Appendix F was changed to include the internal friction angle of the GCL materials. A revised Table 1 for the Geosynthetic CQA is included as Attachment 10.

PART III COMMENTS

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
22.	The laboratory testing data summary for borings GB-1, through GB-4 and PZ-1 presented as Table 1 in the December 2, 1999 site characterization report was omitted from the final version. This information needs to be included in the final version of the report.	Attachment 14 includes the omitted information from the draft design report.
25.	Section 4.2.6 states that the highest groundwater elevation observed at the site was over 8 feet below the proposed secondary liner elevation (now at elev. 398.8 feet). The information in Table 2 of Appendix A, and on the geologic cross section in the November 3, 2000 submittal, indicates this statement is not correct (Table 2 indicates groundwater was as high as 397 feet). Therefore, the narrative in this section should be revised, as it is misleading.	The narrative in Section 4.2.6 of the Design report will be revised as indicated below; "Excess hydrostatic pressure is not expected to affect the containment cell. <u>The highest observed groundwater elevation (based on measurements obtained from an uncased borehole) is approximately El 397 feet, which is below the secondary lining elevation for the cell.</u> The maximum flood elevation……" A revised Section 4 is included as Attachment 2.
60.	Tables 1 and 2 in Specification 02245 (GCLs) the April 2, 2001 Design Report are not the same as the Tables in Appendix 13 in the January 22, 2001 Response to Comments Part III submittal. The record of comments to the draft design report does not indicate a reason for this difference. While it is acceptable, and even preferable, to have separate tables for the two GCLs that will be used, the specification	

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
	for the minimum internal friction angle that was in the Response to Comments Part III were omitted from the tables in Revision 2 of Specification 02245. Several other changes were also made to this specification. Therefore, Specification 02245 and Section 6.2 (where applicable) need to be revised to address the following comments:	
a	Table 1 in the Response to Comments Part III that defined the properties of the Bentonite and geotextiles used in the GCL should be included in Specification 02245 – for both GCLs.	Tables 1 and 2 were changed to better conform to current industry practice of reporting test data for GCL materials as a composite not as separate geotextiles and bentonite material. Tables 1 and 2 in Specification 02245 were changed to identify the geotextile and bentonite material properties to be measured. A revised Specification 02245 is included as Attachment 15.
b	Some explanation needs to be provided for why the required value for grab strength was reduced from 150 to 90 lbs and the frequency for testing permeability changed from 1/1,000,000 ft^2 to weekly in Specification 02245.	The material requirements of the GCL were changed to a product that would more cost effectively meet the requirements of the project without compromising the integrity of the design.
c	The minimum internal friction angle (hydrated internal residual shear resistance), testing frequency, etc. need to be provided for both	The tables in Specification 02245 were modified to include the internal friction angle for both reinforced and non-reinforced GCL materials.

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
	GCLs.	A revised Specification 02245 is included as Attachment 15.
d	Section 3.3, Installation, in Specification 02245 needs to clearly state which GCL gets installed on the base of the landfill, which one goes on the side slopes, and if on side of the GCL is required to be on top.	Specification 02245 was modified to require reinforced GCL materials be placed on slopes steeper than 7 to 1 (H:V). Section 3.3 was modified to read as follows: A. "Reinforced GCL materials shall be placed on slopes steeper than 7 to 1 (H:V). Non-reinforced GCL materials may be used on slopes flatter than 7 to 1 (H:V)." A revised Specification 02245 is included as Attachment 15.
e	Section 6.2 Conformance Testing of GCLs in Appendix F needs to be revised to state that conformance tests will be performed in accordance with the test methods <u>and frequencies</u> indicated in the specifications. The wording "other tests required by the project specifications" in this section should be revised to clearly indicate what these other tests are. Also, note that the minimum value and testing frequency for thickness are not specified in Specification 02245.	The last paragraph of Section 6.2 Conformance Testing of GCLs in Appendix F will be modified to read as follows; "These conformance tests will be performed in accordance with the test methods <u>and frequencies</u> indicated in the specifications. <u>All</u> conformance tests required by the project specifications <u>or the CQA manual</u> shall be performed." A revised Section 6 of the Geosynthetic CQA Manual is included as Attachment 6.
f	The conformance testing in Section 6.2 of Appendix F needs to be revised to include determination of the internal friction angles of both GCLs once they are on-site.	Section 6.2 of the Geosynthetic CQA Manual will be modified to include conformance testing for the internal friction angle of the GCL materials. Item 6 will be added to that section as follows:

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
		"6. Internal friction angle of the Geosynthetic Clay Liner materials after delivery to the site." A revised Section 6 is included as Attachment 6.

NEW COMMENTS

COMMENT	EPA/IEPA DISCUSSION OF RESPONSE TO COMMENTS	SOLUTIA RESPONSE
Appendix F	Section 7, Liner System Acceptance, of the CQA Manual for Installation of Geosynthetic Components is missing.	Section 7 Liner system Acceptance was inadvertently left out of the document. That section is included as Attachment 16 to this response.

LIST OF ATTACHMENTS

ATTACHMENT 1

DESIGN REPORT (SECTION 2: BACKGROUND)

Solutia Inc. has entered into a Unilateral Action Order (UAO) agreement with Region V of the U.S. Environmental Protection Agency (EP) to address concerns regarding affected sediments and soils in and adjacent to Dead Creek in Cahokia, Illinois. The sediments within Dead Creek are part of a larger Superfund Site known as Sauget Area 1. The UAO requires removal of the affected sediments from the creek and transfer to a TSCA compliant disposal facility. The disposal facility will be located adjacent to Dead Creek on land owned by Solutia within the segment known as CS-B. Removal of the affected sediments and transfer to the disposal cell is being performed under the UAO on an emergency basis. Figures 2-1 and 2-2 present the location and vicinity of the project site.

This report addresses the design, construction and operation of the disposal cell. The design was prepared to respond to Exhibit 2 of the UAO. The following table demonstrates how the requirements of Exhibit 2 of the UAO are addressed.

Exhibit 2	Design Report	
1. Design, Construction and Operation Requirements for Containment Cell		
a. Sediment Description	Note 1	
b. Liner System		
• Liner System Description	Section 4.1.1	Liner System Description
• Liner System Location Relative to High Water Table	Note 2	
• Loads on Liner System	Section 4.3.2	Synthetic Liner Strength
• Liner System Coverage	Section 4.1.4	Lining System Coverage
• Liner System Exposure Prevention	Section 4.1.5	Lining System Exposure
c. Foundation		
• Foundation Description	Section 3.0	Site Characterization
• Subsurface Exploration Data	Section 3.3	Subsurface Conditions
• Laboratory Testing Data	Section 3.2	Geotechnical Testing
d. Engineering Analysis		
• Settlement Potential	Section 4.2.1	Settlement Potential
• Bearing Capacity	Section 4.2.2	Bearing Capacity
• Stability of Landfill Slopes	Section 4.2.3	Cell Slope Stability
• Potential for Excess Hydrostatic or Gas Pressure	Section 4.2.6	Potential Excess Pressure
e. Synthetic Liners		
• General Information	Section 4.3.1	General Information
• Synthetic Liner Compatibility Data	Note 3	
• Synthetic Liner Strength	Section 4.3.2	Synthetic Liner Strength

• Synthetic Liner Bedding	Section 4.3.3	Synthetic Liner Bedding
f. Geocomposite Liner (GCL)		
• Description	Section 4.4.1	General Information
• Material Testing Data		
• GCL Liner Compatibility Data	Note 3	
• GCL Liner Strength	Section 4.4.2	GCL Strength
g. Liner System, Leachate Collection and Detection System		
• System Operation and Design	Section 4.5.1	System Operation & Design
• Equivalent Capacity	Section 4.5.2	Equivalent Capacity
• Grading and Drainage	Section 4.5.3	Grading and Drainage
• Maximum Leachate Head	Section 4.5.4	Maximum Leachate Head
• System Compatibility	Note 3	
• Stability of Drainage Layers Layers	Section 4.5.5	Stability of Drainage
• Strength of Piping	Section 4.5.6	Strength of Piping
• Prevention of Clogging	Section 4.5.7	Prevention of Clogging
h. Liner System, Construction and Maintenance		
1) Material Specifications	Section 6.1.1	Material Specifications
- Synthetic Liner Specifications		
- GCL Liner Specifications		
- Leachate Collection/Detection		
- System		
2) Construction Specifications	Section 6.1.2	Construction Specifications
- Liner System Foundation		
- GCL Liner		
- Synthetic Liner		
- Leachate Collection/Detection		
- System		
i. Construction Quality Control Program	Appendix F and Appendix G	
j. Maintenance Procedures for Leachate Collection/Detection System	Note 4	
k. Liner Repairs During Operation	Specification 02244	
1) Run-off Control Systems		
- Design and Performance	Section 5.5.1	Design and Performance
- Calculation of Peak Flow	Section 5.5.1.1	Calculation of Peak Flow
- Management of Collection and		
- Holding Units	Section 5.5.1.2	Collection & Holding Units
- Construction	Section 5.5.1.3	Construction
- Maintenance	Section 5.5.1.4	Maintenance

- Control of Wind Dispersal	Section 5.6	Control of Wind Dispersal
2) Closure and Post-Closure Requirements		
a) Closure Requirements		
- Closure Plans	Section 5.1	Closure Plans
- Closure Performance Standards	Section 5.2	Performance Standard
- Cover Design	Section 5.3	Cover System Description
- Minimization of Liquid Migration	Section 5.4.2	Minimization of Migration
- Maintenance Needs	Section 5.4.3	Maintenance Needs
- Drainage and Erosion	Section 5.4.4	Drainage and Erosion
- Settlement and Subsidence	Section 5.4.5	Settlement & Subsidence
- Freeze/Thaw Effects	Section 5.4.6	Freeze/Thaw Effects
b) Post-Closure Requirements	Note 5	
- Post-Closure Plan		
- Inspection Plan		
- Post-Closure Monitoring Plan		
- Post-Closure Maintenance Plan		
- Notice in Deed and Certification		

Notes:

1) Time Critical Removal Action Work Plan, Section 3.0 Sediment Chemical Analyses and Bioassays

2) Time Critical Removal Action Work Plan, Section 2.8, Groundwater Levels

3) Compatibility tests were completed and are included as Appendix J.

4) System is designed to minimize maintenance so description of maintenance is needed.

5) Post-closure will be addressed in the O&M Plan which is due 60 days after completion of cell construction.

A groundwater monitoring plan for the TSCA containment cell is being reviewed concurrently with construction of the containment cell.

Design data, contaminant cell construction requirements and all details referenced in the following text is located in the appendices. A brief listing of the information included in each follows:

Appendix A	Site Characterization
Appendix B	Foundation Evaluation
Appendix C	Liner System Component Design
Appendix D	Cover System Component Design
Appendix E	Technical Specifications
Appendix F	Construction Quality Assurance Manual for Installation of Geosynthetic Components
Appendix G	Construction Quality Assurance Manual for Installation of Soil Components of the Lining and Final Cover Systems
Appendix H	Geosynthetic Material Data Sheets
Appendix I	Technical Information on Performance of Geosynthetic Clay Liners
Appendix J	Material Compatibility Study

ATTACHMENT 2

DESIGN REPORT (SECTION 4.0: LINER DESCRIPTION AND SYSTEM DESIGN

4.1 LINER SYSTEM

The bottom liner system for the proposed containment cell will be a multi-component composite lining with leachate collection and leak detection layers. A description of the components is provided below.

4.1.1 Description

The proposed landfill liner system on the base of the cell will consist of the following layers (top to bottom):

- 18-inch thick sand layer
- Non-woven geotextile fabric
- Geonet drainage layer
- 60-mil HDPE (smooth)
- 12-inch tracked in place soil
- Non-woven geotextile
- Geonet drainage layer
- 60-mil HDPE (textured)
- Geosynthetic clay liner (GCL)
- 6-inch tracked in place soil
- Nonwoven geotextile
- 36-inch thick gravel layer
- Subgrade or compacted fill

The proposed landfill liner system for the side slopes of the cell will consist of the following layers (top to bottom):

- Non-woven geotextile fabric
- Geonet drainage layer
- 60-mil HDPE (smooth)
- Geonet drainage layer
- 60-mil HDPE (textured)
- Geosynthetic clay liner (GCL)

- Compacted fill

Figure 4-1 shows the proposed configuration of the bottom lining system. Figure 4-2 presents the proposed configuration of the side slope liner system. HDPE membrane will be manufactured by GSE, Serrot or equivalent. Geotextile will be manufactured by Mirafi or equivalent. Geonet and geogrid will be manufactured by Tenax or equivalent. GCL will be manufactured by CETCO, GSE, Serrot or equivalent. Manufacturers technical data sheets for these geosynthetics are included in Appendix H.

The subgrade soils will be graded to mirror the intended bottom grades for the completed bottom liner. An earthen berm will be constructed around the limits of the proposed containment cell to form the side walls of the cell. The upper 12 inches of the subgrade soils and all the earthen berm fill will be compacted to at least 95 percent of the soil's maximum dry density as determined by ASTM D698.

A capillary break layer consisting of 36 inches of gravel will be placed over the prepared subgrade. The gravel will conform to an ASTM C-33 gradation for coarse aggregates. The gravel will be tamped in place by the construction equipment. No additional compaction will be required. The capillary break layer will not be constructed on the containment cell side slopes.

After placing a geotextile on top of the capillary break layer, a 6-inch native fill layer will be pushed and tracked into place over the capillary break layer. Tracked in place fill shall consist of native soils with clods no greater than two inches compacted to 90 percent of Standard Proctor maximum density with moisture contents at or near optimum. The containment cell side slope berms will be constructed of compacted native fill. The tracked in place soil and the compacted fill will serve as the foundation (bedding layer) for a Geosynthetic Clay Liner (GCL). This bedding layer will have clods no larger than two inches, will be placed and compacted to at least 90% Standard Proctor Density with moisture contents at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system. The GCL will be rolled into place and overlapped with adjacent panels.

A textured 60-mil High Density Polyethylene (HDPE) liner will be placed directly over the GCL to serve as the secondary lining system. The HDPE lining panels will be heat seamed to form a continuous membrane barrier. The seaming will be either pressure or vacuum tested to verify the integrity of the seams. Mechanical tests of the seam integrity will be performed by removing test samples from the completed lining and destructively testing the samples. The lining sample locations will be patched with an extrusion welded HDPE patch.

A geonet synthetic drainage composite will be installed over the secondary lining system to serve as the leak detection layer. A nonwoven geotextile will be placed over the geonet to prevent soil intrusion into the leak detection materials. At least 12 inches of native soil will be tracked in place over the leak detection layer on the cell bottom. The tracked in place soil layer will serve as the bedding layer for the overlying geosynthetic materials. Bedding layer soils will have clods no larger than 2 inches, will be placed and compacted to 90 percent Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system. The tracked in place soil layer will not be installed on the containment cell side slopes.

A smooth 60-mil HDPE lining will be placed on the tracked in place soil layer on the cell bottom to serve as the primary lining system. The HDPE lining will be placed directly over the geonet drainage layer on the cell's side slopes. The HDPE lining panels will be heat seamed to form a continuous membrane barrier. The seaming will be either pressure or vacuum tested to verify the integrity of the seams. Mechanical tests of the seam integrity will be performed by removing test samples from the completed lining and destructively testing the samples. The lining sample locations will be patched with an extrusion welded HDPE patch.

The primary collection system will consist of a geonet and geotextile combination placed directly over the primary HDPE liner on the base and side slopes of the containment cell. At least 18 inches of sand will be placed over the geotextile/ geonet combination to form the primary leachate collection system in the bottom of the containment cell. No compaction will be performed on the sand layer. The minimum hydraulic conductivity of the sand will be 1×10^{-3} cm/sec. Rounded pea gravel will be substituted for the sand around the perimeter of the cell bottom to provide higher transmissivity for leachate removal.

Leachate collection on the cell's side slopes will be provided by a geonet/ geotextile drainage composite to prevent soil clogging. The hydraulic transmissivity of geonet is at least 5 cm/sec. The wastes placed in the containment cell will directly contact the drainage composite on the side slopes. To insure that the side-slope liner system is not punctured, excavated sediment in contact with the cell side slopes will be screened to remove material larger than 2 inches including sticks, trash and other sharp objects. While spreading sediments in the bottom of the cell, a bank of screened sediment will be placed 2 to 3 feet high and 2 to 4 feet thick at the toe of the slope. This bank of screened sediment will protect the side-slope liner system. When the fill reaches the height of this bank, another one will be constructed of screened sediment at the toe of the slope to protect the side-slope liner system.

As indicated previously the primary liner system on the side slopes of the landfill will be similar to that designed for the bottom. The tracked in-place clay layer beneath the primary geomembrane liner will not extend up the side slope. In addition, the primary collection system will consist of a geonet and geotextile placed directly on the primary geomembrane liner. Figure 4-2 presents this configuration.

The lining and geonet layers will be buried in anchor trenches at the top of slope around the containment cell.

The designed capacity of the containment cell is 50,000 yd^3. Calculations demonstrating this are provided in Appendix B.

4.1.2 Liner System Location Relative to the High Water Table

A piezometer installed at the proposed containment cell location has been used to monitor the groundwater depth at the site from November 1999 through April 2000. The groundwater level was observed fluctuating between 9.5 and 12.45 ft below ground surface (about elevations 392.5 and 389.55 ft). The minimum elevation of the secondary lining system will be 398.8 ft. Details of measured groundwater levels at this site are presented in Appendix A.

4.1.3 Loads on Lining System

The loads on the lining system were evaluated to determine if they could damage the lining system. The following paragraphs describe the various loads and results of calculations for those loads. Calculations demonstrating the estimated loads on the liner system are included in Appendix C.

Internal and external pressure gradients were evaluated. Two methods for the cell to experience a pressure gradient are envisioned, gas evolution from waste decomposition and barometric pressure change. The containment cell cover system will incorporate a vent system to equalize the internal and external pressure and to vent gases generated in the wastes. The overburden soil on the cover system exerts a vertical stress of over 200 psf on the cover lining. Therefore, the cover lining is not likely to balloon due to barometric pressure change of less than 3 inches of mercury. Gas generation from the waste material is anticipated to be minor since the wastes are largely inorganic or previously decomposed. The vent system will allow generated gas to exit the cell without pressure buildup. Gas vents will penetrate a minimum of 18 inches into the compacted sediments.

Lining systems may be ruptured by excessive deflection from foundation uplift or differential settlement. The 100-year flood elevation for this area is reported to be about elevation 406 ft. Based on a minimum secondary lining elevation of 398.8 ft, the lining system should not uplift as long as there is at least 4 ft of soil lining components or waste over the secondary lining. Damage to the lining system by uplift is not likely.

Differential settlement of the containment cell bottom can elongate the HDPE linings beyond their strain capacity. As shown in the settlement analyses below, the differential settlement is expected to be less than 1-inch. The bottom settlement is anticipated to assume a spherical shape. The bottom lining along the side wall embankments will settle little while the lining settlement increases to the center of the cell. The bottom settlement produces a lining strain of less than 0.1 percent. This lining strain is much less than the elastic strain limit (about 4 percent) and the plastic strain limit (about 700 percent) of the HDPE lining material. Differential settlement is not likely to damage the lining system.

Static and dynamic loads should not affect the lining system. The relatively minor waste thickness produces only minor static loads on the lining system. The loading from the wastes, cell cover, and proposed post-closure land use are well within the lining system's capability. Dynamic loads from construction and earthquakes are anticipated. Specifying a minimum cover soil thickness between any equipment and the lining will control dynamic loading of the lining system. Additionally, an engineered side slope protection layer will be incorporated in the cell where equipment traverses the slope or soil will be pushed or dumped down the slope. Earthquake accelerations in this area are minor and are not anticipated to cause any damage to the lining system. Earthquake analysis is provided in a later section of this report.

4.1.4 Lining System Coverage

The lining system at this site is designed to cover the entire footprint of the proposed containment cell. Since this facility will be an above grade disposal unit, perimeter berms will completely surround the cell. Figure 4-3 presents a plan of the site preparation required to achieve the desired disposal capacity for the site. Figures 4-4 and 4-5 present the secondary and primary geomembrane layouts for the cell. A plan view of the primary collection system coverage is shown on Figure 4-6. Figure 4-7 presents the details of the liner system proposed anchorage at the crest of the perimeter containment levee. Design calculations demonstrating the capacity of the anchor system (presented in Figure 4-7) are included in Appendix C.

Wastes will only be placed within the lined containment cell. Leachate collection and leak detection systems will control and collect all liquids from the cell. No wastes or leachate will contact the surrounding ground.

4.1.5 Lining System Exposure Prevention

Certain synthetic components in the proposed lining system can be injured by various environmental exposures. Two potentially damaging environmental exposures are sunlight and wind. Sunlight can degrade unprotected plastics and polymers. Wind can displace and damage placed materials due to uplift causing pinholes, wrinkles and weakened locations at folds. The HDPE membrane linings will not be exposed for more than about 4 to 6 months on the containment cell side slopes.

Wind damage to the geosynthetic liner systems is another potentially significant problem resulting from exposure to the elements. Damage to geosynthetics is typically due to displacement after the material has been installed. Prevention of this potential damage will be managed by placement of the succeeding soil / sand layer on the base of the landfill and via the use of sandbags on the side slopes of the cell.

Geotextile fabrics are susceptible to sunlight degradation. Several steps will be put into place to avoid extended sunlight exposure. Where possible, the geotextiles will be covered with soil as soon as possible after placement. The maximum sunlight exposure period will be 2 weeks. The geonet leachate collection layer on the cell's side slopes may not be covered with wastes for 4 to

6 months. Therefore, the side slope geonet drainage composite will be covered with an opaque plastic sheet until wastes are placed on the geonet. Sandbags will anchor the plastic sheeting over the geonet.

The GCL lining is composed of two geotextiles sandwiching bentonite clay. The GCL has sun and precipitation exposure limitations. The GCL installation will be conducted so that the GCL is covered with the HDPE lining within one day of placement.

Installation requirements for placement of GCL materials includes the following:

- Do not place GCL in the rain or at time of impending rain
- Do not place GCL in areas of ponded water
- Replace GCL that is hydrated before placement of overlying geomembrane layer
- In general, only deploy GCL that can be covered during that day by geomembrane or a minimum of twelve (12) inches of approved cover soil.

Technical information demonstrating the behavior of GCL materials is included as Appendix I.

4.2 ENGINEERING ANALYSES

4.2.1 Settlement Potential

As previously described, the soil conditions are relatively good with respect to settlement potential of the proposed containment cell. The relatively thin surficial clay and silt layers have little settlement potential. The underlying sands and silty sands are generally medium dense to dense with minor settlement potential. Regionally, the depth to bedrock is known to be about 120 ft below ground surface. These factors reduce the settlement potential at the site.

The small proportion of silt and clay soil thickness in the subsurface profile indicates that most deformation beneath the containment cell will be due to immediate settlement. Consolidation settlement will not be a significant factor at this site.

The proposed containment cell will be founded on the existing foundation soils between 395 and 407 ft elevation.

The embankment surrounding the cell will be constructed first and the lining system and wastes placed last. The embankment is expected to undergo most of its settlement during its construction. The embankment is expected to settle about 2.5 inches during its construction. The bottom lining system will settle about 2.5 inches at the center of the bottom and about 1.5 inches at the bottom perimeter. The differential bottom settlement is about 1-inch. The anticipated differential settlement of the bottom lining should produce a grade change of less than 0.05 percent. The differential settlement should not adversely affect the lining integrity or drainage. Details of this analysis are presented in Appendix B.

4.2.2 Bearing Capacity

The surficial clay and silt samples collected at the site were found to have undrained shear strengths ranging from 250 to 440 pounds per square foot (psf). Those strengths indicate soils with soft to firm consistency. The underlying sandy soils were observed to be very loose to medium dense. The limiting bearing capacity strata was found to be the surficial clays and silts. Based on the minimum undrained shear strength above, the ultimate bearing capacity of the existing subgrade soils is about 1,300 psf. Details of this evaluation are presented in Appendix B.

4.2.3 Containment Cell Slope Stability

The embankment slopes for the containment cell will be constructed from compacted natural fill obtained onsite or imported to the site. The minimum undrained shear strength of the embankment fill is estimated to be 1000 psf. The peak ground surface horizontal acceleration used in the stability calculations is 0.16g.

Slopes excavated below existing grade will have a slope angle no steeper than 3 horizontal to 1 vertical (3:1). The maximum depth of excavated slopes is about 10 ft below existing grade. For an undrained shear strength of 480 psf, the stability of this slope is estimated to have a factor of safety of greater than 20 under both static and seismic conditions. Excavations with side slopes flatter than 3:1 will have no stability concerns.

As shown in Figure 4-3, the containment cell will be constructed mostly above grade with an earthen embankment surrounding the cell. The exterior slopes of the embankment will be no steeper than 4:1. The maximum height of the 4:1 exterior embankment slopes will be about 20 ft. The factors of safety for the exterior embankment slope are 2.5 and 1.5 for the static and seismic conditions, respectively.

The interior slopes of the containment cell will be no steeper than 3:1. The maximum height of the interior slopes prior to lining system placement is about 12 ft. Factors of safety for the lining system slopes was calculated to be greater than 1.5 for a veneer of waste placed in thicknesses of less than 2 ft and in lengths of 10 ft or less on the slope.

The containment cell lining system will not be constructed over any waste materials. The containment cell cover system will have minimum and maximum surface slopes of 3 to 12 percent, respectively. The interface friction angle between the geonet drainage media and the HDPE lining was assumed to be about 16 degrees. Calculations of short-term loading and long-term loading are presented in Appendix C. Information on the typical performance of geosynthetic clay liners is included in Appendix I.

Interface friction testing will be performed by the Contractor as part of the conformance testing required by the CQA Manual. This testing will be performed in accordance with ASTM D5321 and will include the following material combinations:

- Textured HDPE / geosynthetic clay liner
- Textured HDPE / geonet
- Smooth HDPE / geonet
- Smooth HDPE / compacted soil
- Geosynthetic clay liner / compacted soil

The selected Contractor will be required to submit conformance test results within "30 days of contract award."

4.2.4 Seismic Conditions

U.S. Geological Survey (USGS) Hazard Maps show this area has a peak bedrock acceleration (PGA) of 0.1g. The earthquake magnitude for this region is estimated as 6.5. The subgrade soils at the site do not have liquefaction potential based on the PGA and magnitude estimated for this area. Details of our evaluation of seismic loading impacts are presented in Appendix A.

4.2.5 Subsidence and Sinkhole Potential

Subsidence and sinkholes are not expected in this region. Neither karstic geology nor mining activity are present in this region.

4.2.6 Potential for Excess Hydrostatic or Gas Pressure

Excess hydrostatic or gas pressure is not expected to affect the containment cell. The highest groundwater elevation (based on measurements obtained from an uncased borehole) is approximately El 397 feet, which is below the secondary lining elevation for the cell. The maximum flood elevation for this area is reportedly elevation 406. After the lining system is complete, the static weight of the soil layers in the lining system exceeds the potential hydrostatic uplift pressure. No heaving of the lining system is anticipated. Calculations demonstrating this point are included in Appendix B.

The potential for gas pressure within the containment cell is low due to the relatively low quantity of decomposable matter in the wastes compared to a sanitary waste landfill. A venting system will be incorporated into the cover system to vent excess gas or barometric pressure from within the containment cell.

4.3 SYNTHETIC LINERS

4.3.1 General Information

The primary and secondary linings in the bottom lining system and the primary lining in the cover system will be constructed with 60-mil HDPE membrane. The HDPE liners will be either textured or smooth surfaced and all will contain ultraviolet protectants. Although the HDPE manufacturer for this installation is currently undefined, manufacturers such as GSE Lining Technology or Poly-Flex Inc. produce linings meeting the requirements of the State of Illinois.

4.3.2 Synthetic Liner Strength

Two loading conditions are anticipated for the synthetic linings, soil loading on side slopes and settlement of the bottom liner system. Calculations were performed to evaluate these two conditions.

The linings on the cell's side slopes will be insulated from downdrag from the overlying waste material by a geonet drainage composite. Calculations in Appendix C (Lining Tensile Stress) for the lining stress due to the weight of soil sliding down the side slope show that the lining stress stays below the HDPE yield stress. Once wastes are placed and compacted in the cell, little down slope soil movement will be possible. This further limits the probability of lining downdrag. The cell construction specifications will prohibit dumping soil down unprotected side slopes. Where placement traffic on the side slope is required, the slope will be protected by geogrid reinforcements and additional HDPE fly sheets. As presented in Appendix C the side slope lining stress will be less than the yield stress of the HDPE geomembrane liner material. Lateral seams in the lining panels will be prohibited on the side slopes.

Settlement of the bottom lining was previously identified to be minor. The strain in the bottom lining due to settlement as presented in Appendix C is well within the elastic limit for the HDPE lining. Settlement calculations in Appendix A and Appendix B of the final design report indicate that differential settlement of the base of the containment cell after construction and waste placement will be approximately 2 inches. This translates into an elongation in the HDPE of approximately 1.3×10^{-5} in/in. Assuming an HDPE modulus of 30,000 psi the stress increase in the bottom lining is expected to be about 30 psi for each 0.1 percent strain. These values are far less than the yield strain of 13 percent for the geomembrane. As demonstrated in Appendix C the bottom linings will not be overstressed.

Synthetic lining seaming will be performed using either hot-wedge or extrusion welding. Either method will be required to provide a film-tearing bond (FTB) in the parent HDPE linings. The strength of these seams will be required to achieve at least 90 and 50 percent of the HDPE lining tensile strength in shear and peel, respectively. The seams will be destructively tested periodically as provided in the Construction Quality Assurance Plan. All seams will be tested for hydraulic integrity using vacuum, air-pressure, or electrical methods. Appendix C presents details of this analysis.

4.3.3 Synthetic Liner Bedding

Synthetic linings will be placed on select soil layers, GCL, or geonet drainage composite for the containment cell construction. Figure 4-8 presents typical sections for the bottom and slope lining system showing the proposed linings and bedding configurations. Soil bedding will be free of debris and particles prior to synthetic liner deployment. A wide range of soils, including sand, can be used as bedding material for geosynthetics. Specification 02200 - Earthwork, included in Appendix E, Technical Specifications, will be used for the geosynthetic bedding layers in the liner system. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.

4.4 GEOSYNTHETIC CLAY LINING (GCL)

4.4.1 General Information

The GCL used to construct the containment cell will be a commercially available material composed of two geotextile layers sandwiching bentonite clay granules. The hydraulic conductivity of the GCL will be no greater than 1x 10^{-8} cm/sec. Where high internal shear strength is required from the GCL, the geotextiles will be stitched together. The GCL placed on the containment cell side slopes will have an internal shear strength of 500 psf (nominal) and a tensile grab strength of at least 80 pounds. The GCL placed on the cell bottom and in the cover will have an internal shear strength of 50 psf (nominal) and a tensile grab strength of at least 50 pounds. Lateral and longitudinal seams will be completed by overlapping adjacent panels.

4.4.2 GCL Strength

The GCL material type will be tailored to meet the strength requirements of the location. The GCL used on side slopes will have 500 psf internal shear strength. Lateral seams will not be located on the side slopes, only continuous GCL panels. The lower internal shear strength GCL is suitable for all bottom and cover locations. The GCL material will not undergo any tensile loading. All tensile stresses will be transferred through the GCL via the internal shear strength to the underlying soil layers. Appendix C presents the results of this analysis.

Short-term and long-term strength of the GCL is presented in Appendix C for the loading conditions anticipated. Technical information on GCL performance is included in Appendix I. Interface shear testing will be performed to identify site specific behavior for GCL/HDPE and GCL/compacted soil combinations.

4.5 LINER SYSTEM, LEACHATE COLLECTION AND DETECTION SYSTEM

The containment cell will incorporate a leachate collection and leak detection system. Details of the systems are provided below.

4.5.1 System Operation and Design

The leachate collection system over the primary lining system will consist of 18 inches of sand placed over a geonet/ geotextile layer on the cell bottom area. An 18-inch thick by 36-inch wide gravel drain will be located around the bottom perimeter of the cell. Figure 4-6 presents a plan view of this drain and Figure 4-9 presents a cross-section. The gravel will be encased by a geotextile filter. The minimum hydraulic conductivity of the sand will be 1 x 10^{-3} cm/sec. The gravel will be ⅜-inch pea gravel.

The side slopes will have a geonet/ geotextile drainage composite placed directly on the primary HDPE lining. The geonet will intersect the gravel berm at the bottom perimeter. The geonet will be protected during construction by pushing waste material up to the geonet to provide a 2- to 4-ft buffer between the active waste placement and the lining systems on the side slopes.

The gravel drain will be expanded to a plan dimension of 75 ft by 75 ft in a triangular shape to serve as a leachate collection sump. An HPDE pipe will extend from the sump to the top of the completed cover system for periodic leachate removal. A flush-mounted vault will protect the pipe at ground surface. The pipe will be perforated within the limits of the sump.

Leachate-collection system design will be modified to include a high-level alarm set to ensure that leachate levels in the leachate collection system are one foot or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future. Figures 4-10 and 4-11 present the plan and elevation details of the outlet.

As previously indicated the two options for removal of liquids from the cell is a vacuum truck or a dedicated submersible pump. Regardless of the method used, the high-level alarm will be installed into the collection system riser pipe with a dedicated cable. This cable will be marked with a permanent marker to establish the correct depth for the sensor and facilitate repeatability in placing the sensor in the riser pipe. Removal of liquids from each sump will be performed to ensure protection of the sensor.

If a vacuum truck is used the procedures to install and protect the high level alarm are as follows:

- Remove the sensor from the riser pipe.
- Insert the vacuum hose to evacuate the sump.
- When complete remove the vacuum hose and reinsert the sensor to the correct depth.

If a submersible pump is installed in the collection system riser, the high-level alarm will be permanently fixed to the discharge hose of the pump. In this approach the sensor will not need to be routinely removed and replaced into the pipe. However to ensure the sensor is not damaged, the dedicated cable of the sensor will be periodically attached to the discharge hose of the pump along its length. The location of the sensor will be above the intake section of the pump. Figure 4-8 presents the elevation established for the high-level alarm in the leachate collection, leak detection and the capillary relief layers.

The leak detection system will mirror the grading in the leachate collection system. The leak detection layer will include a 20-foot by 20-foot triangular shaped collection sump. The detection system elevation will drop an additional 12 inches to accommodate the gravel sump. The remainder of the leak detection system will consist of a geonet drainage composite. A geotextile filter will be placed over the geonet where the soil layer between the primary and secondary lining systems is located. No geotextile will be placed over the geonet on the side slopes where the primary and secondary linings directly sandwich the geonet. A perforated HDPE pipe will extend from the gravel sump to the top of the completed cover system for periodic leachate removal. A flush-mounted vault will protect the pipe at ground surface. Figures 4-12 and 4-13 present the outlet pipe for the detection layer.

Leachate-detection system design includes a high-level alarm set to ensure that leachate levels in the leachate detection system are one foot or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future.

A 36-inch thick gravel layer will be located beneath the secondary lining system to serve as a capillary break layer. The layer will mirror the grades of the overlying detection system, draining to one corner of the bottom area. The gravel layer will be located only beneath the bottom area of the cell. A perforated HDPE pipe will extend from the gravel sump to an elevation above the 100-year flood elevation where it will exit the cell embankment. A flush-mounted vault will protect the pipe at ground surface.

Capillary break layer design will be modified to include a high-level alarm set to ensure that leachate levels in the capillary break layer are 1-ft or less. When high level conditions occur, a warning light will be activated at the containment cell and an autodialer will notify the O&M contractor of the high level condition. A vacuum truck will then be used to remove the leachate for off-site disposal. Operational experience will be used to determine whether it is more cost effective to use a vacuum truck or a permanent pumping system to remove the leachate. Dedicated pumps are not considered necessary at this time because the volume of leachate that will be generated is not known nor can it be estimated. Riser and horizontal collector pipes are sized to allow pump installation in the future. Figures 4-14 and 4-15 present the plan and elevation detail views of the outlet pipe for the capillary break layer.

Figure 4-16 presents details of the primary collection system and leak detection riser pipes on the side slope of the cell with the required bedding within the liners.

Calculations were performed to establish the volume of sump required in the primary collection system. The sump size was based on a calculation of water balance for the cell. The hydraulic balance for the containment cell was performed using the USEPA computer program Hydrologic Evaluation of Landfill Performance (HELP), version 3.07. Calculations were performed for a short term (construction case) and long term (post closure) case. The HELP model was executed in the construction case using the above liner system configuration overlain by an 80-inch thick sediment layer without the cover system. This modeling scenario in effect models the landfill during the filling activity and represents a worst case scenario. In addition, the following conservative assumptions were made and implemented in the HELP model run:

- 100 percent of the rainfall will infiltrate into the placed fill
- The filled sediments is exposed to the weather with no temporary or permanent cover
- The permeability of the geonet is assumed to be 5 cm/sec.

The construction case simulation indicates that much less than 12 inches of leachate will be generated even under the worst case assumptions made for the evaluation.

The long-term simulation shows that most precipitation is intercepted by the cover system with virtually no leachate being produced. The primary leachate source will be from precipitation during waste placement and entrained moisture in the wastes. The simulation indicates that annual measurement and removal of leachate from the collection and detection systems will be sufficient. A peristaltic pump or vacuum truck should be sufficient to remove the collected leachate. Details of the required sump size are shown in Appendix C.

4.5.2 Equivalent Capacity of Geonet Drainage Composite

The geonet drainage composite used for all side slope collection layers and the leak detection bottom layer will have transmissivity values that are equivalent to that of a 12-inch thick sand layer with a hydraulic conductivity of 1×10^{-2} cm/sec. As demonstrated in Appendix C the geonet transmissivity is almost 2 orders of magnitude greater than the transmissivity of a sand layer.

4.5.3 Grading and Drainage

The primary leachate collection system consists of 18 inches of sand overlying a geotextile and geonet layer. The bottom lining for the leachate collection system will slope at 3 percent beneath the sand layer toward the gravel sump and the gravel perimeter drains. The gravel drains slope at 1 percent (minimum) to a collection sump at one corner of the cell bottom. The grading for the leak detection system generally mirrors the collection system above. As demonstrated in the HELP Evaluation calculations presented in Appendix C, based on conservative assumptions of inflow rate, the amount of leachate head that will develop in the primary collection system is considerably less than 12 inches at the farthest point from the collection sump. This calculation demonstrates that the containment cell does not require piping to achieve the regulatory performance standard for leachate development.

The sumps will be drained through HDPE pipes placed in each sump. The collection pipe will be unperforated from ground surface down to the gravel collection sump and perforated within the gravel collection sump. The piping will match the side slope grade and bend to transition from the slope to the bottom grade. End caps will be placed over the pipe ends to prevent foreign material and gravel entry.

The pipe perforations will be 1/4-inch diameter. The entire length of piping within the gravel sump will be perforated. The 3/8-inch diameter gravel will provide adequate filter action to prevent clogging of the pipe perforations.
The HELP model results indicate that leachate production will be minimal after the cover system is in place. The transmissivity of the sand, gravel, and geonet layers are adequate to rapidly transmit the leachate to the collection sump. The leachate level in each sump will be measured by installed liquid level monitors. Any liquids found in the collection piping will be removed via sump trucks or submersible pumps and placed in drums or tanks for disposal. Collected liquids will be tested to identify the presence of hazardous constituents and disposed in accordance with applicable regulations.

4.5.4 Maximum Leachate Head

The HELP model was used to predict the leachate production and head levels within the cell during construction and after closure. The HELP analysis of the closed landfill included the waste sediment layer in the evaluation of potential leachate generation for both the operating and closed conditions. Initial moisture contents assumed in the analysis were default values assigned by the program. The model results are shown in Appendix C.

The model results show that elevated leachate head may occur within the leachate collection layer during construction. The cell will behave like an open catchment and stormwater will collect on the waste surface. The construction model case assumed no stormwater pumping off the waste surface after rainfall events. As required by the specifications stormwater will be pumped off the waste surface as soon as possible to resume waste placement. The assumption of no surface water runoff and no pumping is therefore highly conservative. The construction model assumed that the cell was half-filled with wastes. Default values for initial soil moisture and hydraulic conductivity were used in the analysis. The leachate collection sump will require pump out after each rainfall event during construction. The construction model indicates the peak leachate generation rate is about 4,000 gallons per day or 2.8 gallons per minute.

The model results show that the leachate leakage into the detection layer during construction is about ¾-inch per year, which produces about 20,000 gallons of leachate in the expected 6-month construction period or about 110 gallons per day. Therefore, the leak detection layer will require checking and possibly pump out every other day during the construction period. The analysis assumed that the head in the leachate collection layer was not drawn down regularly, therefore the leachate leakage rate is conservative.

The model results show the leachate and leak production rates fall substantially after the cover system is installed over the cell. Leachate development and leak production are essentially zero after the cell water balance has reached equilibrium.

Practically 100 percent of stormwater falling on the closed landfill is managed by the cover system system via evapotranspiration. Stormwater that does infiltrate the cover system is absorbed by either the topsoil layer or the contained sediments.

Some leachate production will continue for several months after the cell is covered due to continued gravity drainage of the placed sediments, however this is expected to diminish with time. Installed liquid level controls will continuously monitor the leachate and leak collection sumps. Periodic inspections (weekly or monthly) will be conducted until the production rate has reduced. Annual checks will be conducted thereafter.

4.5.5 Stability of Drainage Layers

The containment cell drainage layers will support the loads in the system. The maximum vertical stress expected for the leak detection layer is about 2,500 psf. The geonet drainage composite is rated for vertical loadings over 20,000 psf. Therefore, the leak detection layer will not be affected by the loading.

The leachate collection system will have a maximum vertical stress of about 2,300 psf. The sand and gravel layers can support many times that vertical stress without crushing. Therefore, the leachate collection layer will not be affected by the loading.

The drainage layers on the side slopes will be geonet drainage composites. These layers will not support significant loading by soil or equipment moving down the slope. Therefore, additional engineering and construction measures are required to perform the cell construction and waste placement. Reinforced ramps to carry the soil and equipment loads may be used. A geogrid reinforcement with an underlying HDPE slip sheet will insulate the geonet and linings from tensile downslope loads. Calculations for the reinforcement are shown in Appendix C.

The geonet drainage composite on the side slopes will be protected during waste placement by pushing the wastes up to the slopes with a minimum separation of 2 to 4 ft between the equipment and side slopes. The wastes will be placed sequentially from the cell bottom to the top and little movement of the wastes on the side slopes is anticipated. Geotextiles used on the drainage composite can commonly reach 50 percent strain before failure and the geonet strain capacity is larger yet. The movement of the wastes due to settlement is not likely to exceed several percent. Therefore, the geonet drainage composite will perform adequately on the side slopes.

4.5.6 Strength of Piping

Piping in the containment cell is limited to the sump drains in the leachate collection, leak detection, and capillary break layers. In all three installations, 6-inch diameter HDPE piping with a SDR of 11 will be used. The worst case loading condition is anticipated to be a wheel loading from a construction vehicle. The tire pressure and width were assumed as 50 psi and 12 inches, respectively. The depth of soil cover was 1-ft. A 1,000 psi soil modulus is representative of a soft clay material. The proposed piping provides factors of safety greater than 7 for the loading condition. The proposed piping will provide acceptable service in the containment cell. The pipe strength calculations are provided in Appendix C.

4.5.7 Prevention of Clogging

Clogging in the leachate collection and leak detection systems is unlikely to affect the performance of the systems. The systems will receive their highest loads during the waste placement with the loading expected to fall to near zero after the cover placement as reported in the Maximum Leachate Head section. The relatively short performance period for the system reduces the effect of clogging on the long-term performance of the cell.

A geotextile and 6-inch sand layer protect the underlying sand and gravel drainage layers in the leachate collection system from clogging due to the waste materials. A geotextile over the geonet drainage composite on the side slopes protects geonet from clogging with the waste materials. Clogging the geotextile on the side slope should not be a concern since the leachate will continue to flow down slope to the bottom collection layer without applying head to the lining system. Calculations indicate that the average opening size for the geotextile selected to separate the contained sediments and soils from the leachate collection system is appropriate for the expected grain size of the Dead Creek sediments.

The hydraulic capacity of the leachate collection and leak detection systems is many times greater than the highest demand placed on the layers. Minor clogging is not expected, but the capacity of the systems should provide adequate liquid drainage. After the cell is covered, the flows are nearly zero and clogging will not significantly limit the systems' performance. An analysis of geotextile clogging is presented in Appendix C."

In our opinion, the use of pipes as the primary leachate collection system will not improve the efficiency of the leachate collection and removal. Based on our experience we do not believe that installation of a piping system for leachate collection is appropriate for the following reasons:

- Potential clogging of pipe perforations.

- Carrying capacity of the pipes is much less that the drain system currently designed for the landfill.
- If a section of the pipe does become clogged, that portion of the collection system is rendered useless until detected and cleaned.

The sand and gravel layer proposed for the Primary LCRS (in addition to the geonet layer proposed for this system) is designed with a high degree of tolerance for clogging. If an area of the primary system was to experience some encrustation or localized clogging, leachate will not be prevented from entering the LCRS geonet layer or the gravel sump for removal from the system. Leachate will not accumulate over the system, the liquid will continue to seek the lowest possible level by flowing around the zone of reduced permeability.

4.6 MAINTENANCE PROCEDURES FOR LEACHATE COLLECTION & DETECTION SYSTEMS

Leachate collection and leachate detection systems were designed to be low maintenance systems. No maintenance is required to ensure that drainage occurs because both systems drain by gravity to their respective collection sumps. Vacuum trucks will be used to remove accumulated liquids from both sumps so no pump maintenance is required. Riser pipes and perforated pipe sections in the collection sumps are large enough to allow pressure washing should fouling occur.

ATTACHMENT 3

TECHNICAL SPECIFICATION 02225
(SEDIMENT MATERIAL HANDLING

SECTION 02225

SEDIMENT MATERIAL HANDLING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Excavation, temporary storage and transport of sediments, soils and subsurface soil materials.

B. Placement and compaction of excavated sediments, soils and subsurface soil materials in the Landfill.

C. All collection, control, temporary storage, testing and discharge of contaminated water associated with waste excavation, treatment, temporary storage, placement and compaction in the waste disposal cell.

D. Procurement, transportation, storage, handling, installation and operation of all equipment and materials necessary for conduct of the work.

E. Health and safety requirements of the project Health and Safety Plan, as well as Solutia's Pensacola Facility plant specific safety requirements.

1.2 DEFINITIONS

A. Sediments: Fine grained solids located within the limits of the Dead Creek remaining after the creek is unwatered and the residual material dewatered and dried.

B. Subsurface Soils: Existing soil material located directly beneath the sediments within the creek that require removal.

C. Contaminated Water: All stormwater falling directly on exposed sediments, stormwater run on contacting sediments or groundwater seepage contacting sediments material during excavation, temporary storage, handling, transport, placement or compaction.

D. Compactive Effort: Energy applied to the sediments or soils after placement in the Landfill by tracked or wheeled equipment.

1.3 SUBMITTALS

A. Excavation and Material Handling

1. Contractor shall submit an Excavation and Material Handling Plan for approval by the Construction Manager.

2. Contractor's Excavation and Material Handling Plan shall address excavation, stockpiling, temporary storage, handling, transport and placement into the Landfill for sediments and soils.

3. The Contractor's plan shall address management of contaminated water and shall be compatible with the water treatment system for this project.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. All equipment and tools used in the performance of this work are subject to the approval of the Construction Manager before work is started.

B. Provide compaction equipment appropriate for the material types to obtain the densities specified.

C. Provide hand-operated compaction equipment in areas closer than 2 feet (ft) from liners or structures to obtain the densities specified.

D. Operate and maintain compaction equipment in accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different type equipment at no cost to the Owner.

E. Provide equipment for mixing and drying out material, such as blades, discs, or other approved equipment.

F. Contractor shall provide and operate dewatering equipment to remove and maintain control of stormwater runoff and keep the work area in an unwatered condition throughout the construction period in a manner approved by the Construction Manager.

PART 3 EXECUTION

3.1 GENERAL

A. All excavations, trenching, and shoring shall comply with the rules and regulations as established by OSHA Construction Safety and Health Regulations 29 CFR, Part 1926.

B. Contractor shall place all processed and temporarily stored sediments in such a manner as to prevent dispersal by wind, water erosion and to minimize the generation of leachate from rainfall.

C. Contaminated water within the confines of the active portion of the TSCA waste disposal cell, waste handling areas, and creek areas shall be controlled, collected, and discharged in accordance with the direction of the Construction Manager.

D. Mixtures of sediments with soils or subsurface soils shall be handled as if the mixture is 100 percent sediment for the purpose of placement and compaction.

3.2 SEDIMENT AND SOIL HANDLING

A. Dewatering/Drying

1. Sediments within the creek shall be dewatered and dried.

2. Contractor shall install dewatering sumps at the locations and in the manner selected by the Construction Manager.

3. Contractor shall maintain the dewatering sumps to promote removal of rainfall runoff and stormwater.

4. The Contractor may use mechanical methods such as discing, harrowing, or stockpiling to hasten the drying process as approved or as directed by the Construction Manager. The sediments shall not be placed into the landfill until dewatered sufficiently to pass the EPA paint filter criteria.

B. Sediment and Soil Excavation

1. Sediment and soils approved for placement in the Landfill shall be excavated, transported, placed and compacted by the Contractor in the manner approved by the Construction Manager.

2. Contractor shall excavate sediments in a coordinated fashion that minimizes the amount of handling and minimizes the potential to spill or generate contaminated water.

3. Subsurface soil materials located beneath the sediments shall be excavated by the Contractor as directed by the Construction Manager.

4. Excavated soils and subsurface soils shall be transported, placed and compacted in the disposal cell by the Contractor.

5. Contractor's Excavation and Material Handling Plan shall include methods and procedures to control and prevent stormwater run on and run off from areas with exposed sediments to adjacent areas.

3.3 PLACING AND SPREADING SEDIMENTS

A. Do not place sediments until the area to receive fill is completed and accepted by the Construction Manager.

B. Place sediment materials to the lines and grades shown on Plans with specified suitable materials.

C. Grade sediments in a manner that will promote positive site drainage and that will direct drainage away from the work and prevent ponding.

D. Uniformly grade areas to provide a finished surface that is smooth, compacted and free of irregularities. Comply with compaction requirements and grade to cross sections, lines and elevations indicated.

E. Place and compact the sediments in the landfill with sufficient compactive effort to provide a minimum undrained shear strength of 500 psf. Sediment shear strength will be measured by the Contractor and observed by the Construction CQA Consultant using either pocket penetrometer or field penetrometer instruments. The Construction Manager reserves the right to require a higher minimum shear strength if field conditions indicate that construction or operation problems will occur.

F. Place screened sediment on the side slope lining to a height of two to three feet above the toe of the slope and to a thickness of two to four feet. Screen these sediments to remove materials two inches and larger including sticks, trash, and other sharp objects. The minimum undrained shear strength requirement shall not apply to sediments placed in this zone. Side slope screened material will be extended to the crest of the landfill, in segments, of two to three feet in length.

G. Compact each lift of fill thoroughly, using appropriate compaction equipment.

H. If tests indicate Work does not meet specified requirements, rework, remove or replace and retest at no cost to Owner.

I. Contractor shall minimize the surface area of placed sediments within the Landfill.

J. Exposed face of placed and compacted sludge shall vary in accordance with the thickness of the exposed fill.

K. Contractor shall place and compact sediment in accordance with the following:

Maximum Elevation Difference in Compacted Sediment Thickness (ft)	Maximum Exposed Sediment Face Slope Angle
5	3.0 (H) to 1 (V)
10	3.5 (H) to 1 (V)
15	4.0 (H) to 1 (V)

L. Contractor shall not place and compact sediment in layers that creates differences in surface elevations of greater than 10 ft.

M. Contractor shall not place sediment in the cell from the top of the berms by pushing sediment down the side slopes.

N. Contractor will place sediments only on the bottom of the cell and push them toward the side slopes.

3.4 PLACING AND SPREADING SOILS

A. Place soil materials to the lines and grades shown on Plans with specified suitable materials.

B. Grade soils in a manner that will promote positive site drainage and that will direct drainage away from the work and prevent ponding.

C. Uniformly grade areas to provide a finished surface that is smooth, compacted and free of irregularities. Comply with compaction requirements and grade to cross sections, lines and elevations indicated.

D. Place and compact the soils in the landfill with sufficient compactive effort to provide a minimum undrained shear strength of 500 psf. Shear strength will be measured by the Contractor and observed by the Construction CQA Consultant using either pocket penetrometer or field penetrometer instruments. The Construction Manager reserves the right to require a higher minimum shear strength if field conditions indicate that construction or operation problems will occur.

E. Place soils adjacent to the side wall lining with a clearance between the construction equipment and lining of between 2 and 4 ft. The minimum undrained shear strength requirement shall not apply to soils placed in this zone.

F. Compact each lift of fill thoroughly, using appropriate compaction equipment.

G. If tests indicate Work does not meet specified requirements, rework, remove or replace and retest at no cost to Owner.

H. Contractor shall minimize the surface area of placed soils within the Landfill.

I. Exposed face of placed and compacted soils shall vary in accordance with the thickness of the exposed fill.

J. Contractor shall place and compact soils in accordance with the following:

Maximum Elevation Difference in Compacted Soil Material Thickness (ft)	Maximum Exposed Soil Face Slope Angle
5	2.5 (H) to 1 (V)
10	3.0 (H) to 1 (V)
15	3.5 (H) to 1 (V)

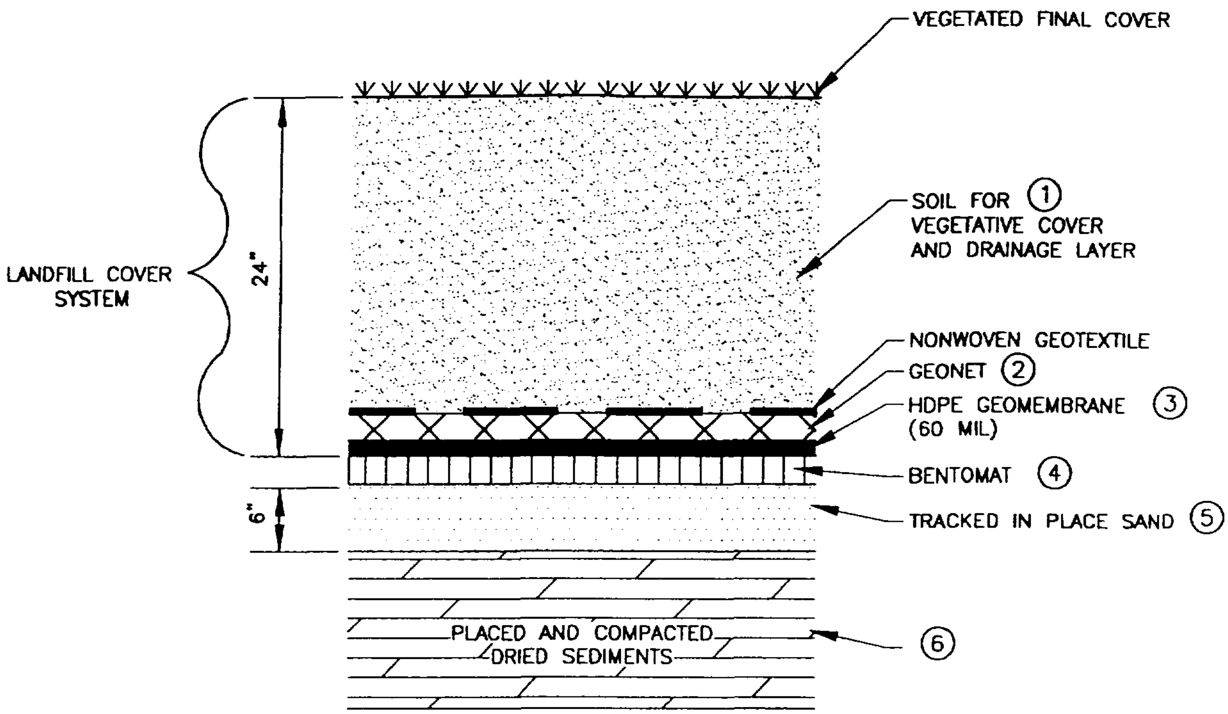
K. Contractor shall not place and compact soil in layers that creates differences in surface elevations of greater than 10 ft.

END OF SECTION 02225

ATTACHMENT 4

HELP ANALYSIS FOR CLOSED LANDFILL CASE AND REVISED FIGURE

HELP EVALUATION DIAGRAM
CLOSED LANDFILL CASE
PAGE 1 OF 12



LEGEND

⑦ HELP ANALYSIS LAYER NO.

THICKNESSES SHOWN ARE
COMPACTED THICKNESSES

NOT FOR CONSTRUCTION

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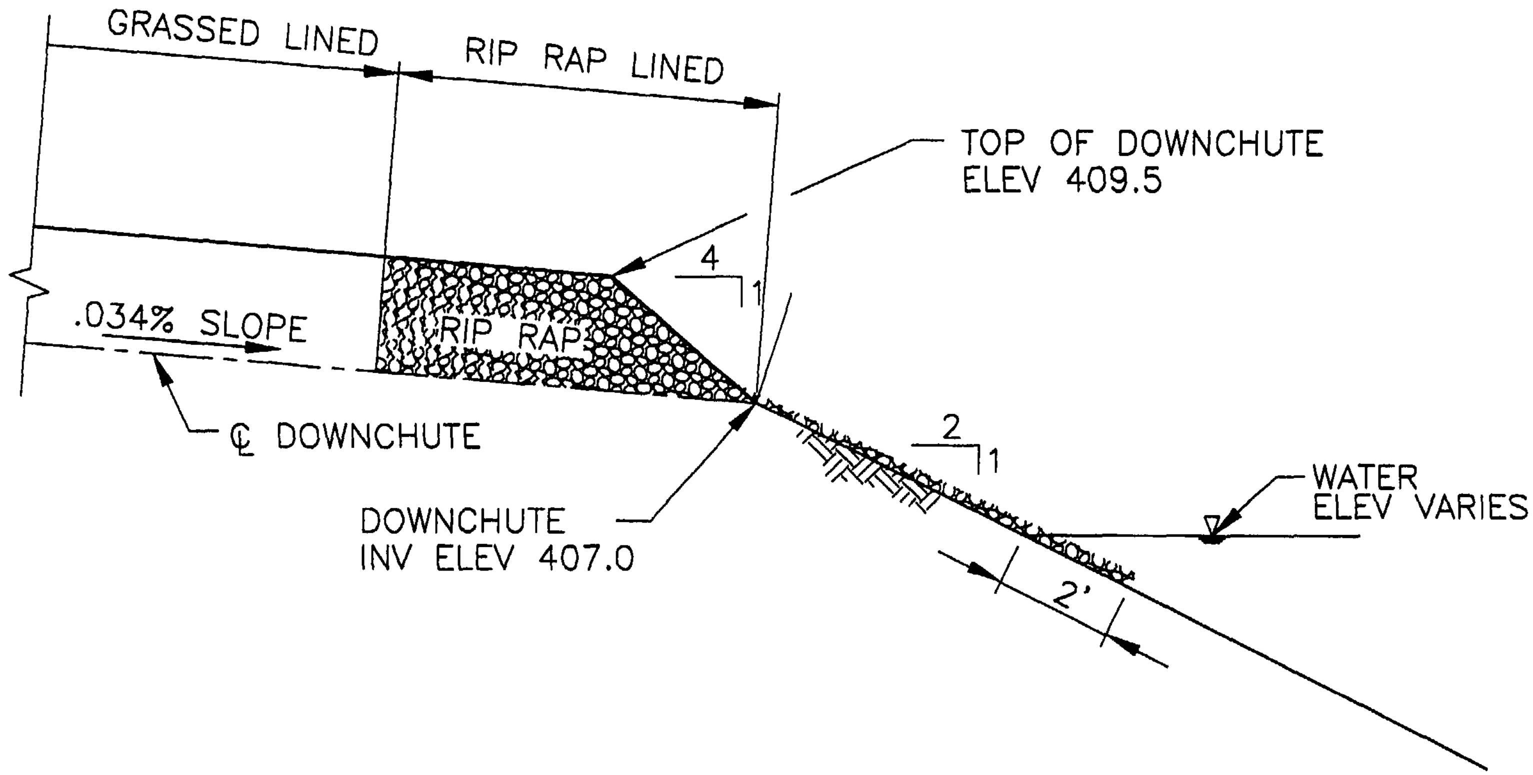
PREPARED FOR: SOLUTIA URSGWC JOB NUMBER: C100003899.00	Drawn: W. WEBER	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE
URS Greiner Woodward Clyde A Division of URS Corporation 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	Design: GARY WANTLAND Checked: GARY WANTLAND Date: JUNE 20, 2000	DRAWING TITLE **COVER SYSTEM DETAIL**	5-2

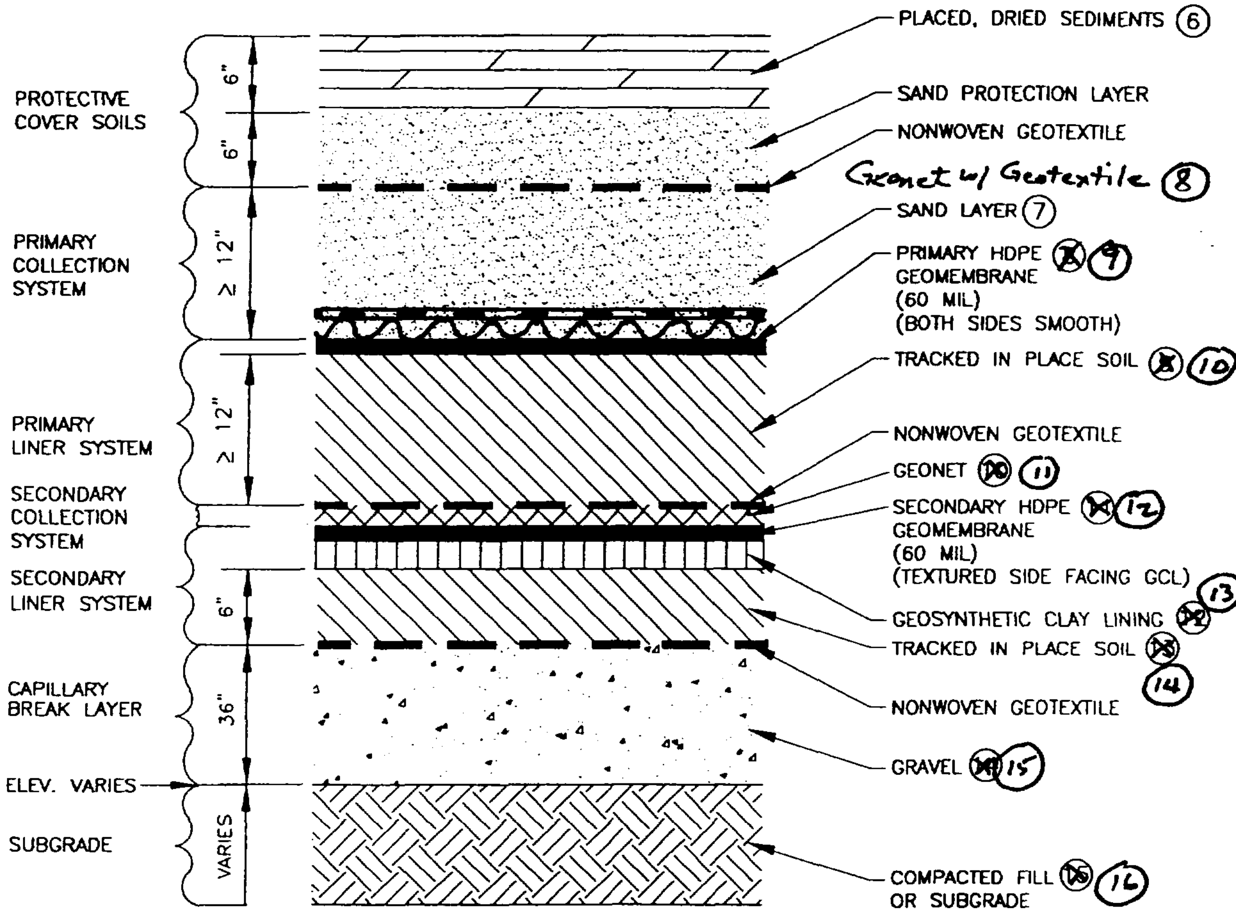


NOTE:
1. NOT FOR CONSTRUCTION.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: BAD Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	DRAWING TITLE **RIPRAP LINED DOWNCHUTE AT DEAD CREEK OUTLET**	FIGURE 5-10

HELP EVALUATION DIAGRAM
~~CONSTRUCTION~~ CASE - CLOSED LANDFILL
PAGE 2 OF 2
(Revised 1 July 01)



LEGEND

(6) HELP ANALYSIS LAYER NO.

(A) BOTTOM LINER SYSTEM DETAIL

C1.4 | C1.6 **N.T.S.**

NOTES
1. NOT FOR CONSTRUCTION
2. LAYER THICKNESSES SHOWN ARE COMPACTED THICKNESS

PREPARED FOR: SOLUTIA	Drawn: R. HAYDEN	PROJECT NAME: SOLUTIA INC. SAUGET AREA 1	FIGURE
URSGWC JOB NUMBER: C100003899.00	Design: M. BRUNGARD		
URS Greiner Woodward Clyde A Division of URS Corporation 7650 W. Courtney Campbell Causeway Tampa, Florida 33607-1462 Tel: 813.286.1711 Fax: 813.287.8591	Checked: G. WANTLAND	DRAWING TITLE: BOTTOM LINER SYSTEM DETAIL	4-1
	Date: OCT. 30, 2000		

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**                                                                          **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07   (1 NOVEMBER 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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TEMPERATURE DATA FILE:       C:\HELP3\examples\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\examples\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\examples\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\examples\DATA10.D10
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TIME:  18:19     DATE:   7/ 6/2001


******************************************************************************

     TITLE:  sauget

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   8
          THICKNESS                   =      24.00   INCHES
          POROSITY                    =       0.4630 VOL/VOL
          FIELD CAPACITY              =       0.2320 VOL/VOL
          WILTING POINT               =       0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT  =       0.2606 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
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FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0352	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	340.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.20	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	168.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03 CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	275.0 FEET

LAYER 9

```
                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.06    INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       2.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       3.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD
```

LAYER 10

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              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   8
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4630 VOL/VOL
FIELD CAPACITY               =       0.2320 VOL/VOL
WILTING POINT                =       0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC
```

LAYER 11

```
                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER  20
THICKNESS                    =       0.25    INCHES
POROSITY                     =       0.8500 VOL/VOL
FIELD CAPACITY               =       0.0100 VOL/VOL
WILTING POINT                =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000       CM/SEC
SLOPE                        =       2.00    PERCENT
DRAINAGE LENGTH              =     275.0     FEET
```

LAYER 12

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 13

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08 CM/SEC

LAYER 14

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03 CM/SEC

LAYER 15

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	36.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	275.0 FEET

LAYER 16

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4630 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 341. FEET.

SCS RUNOFF CURVE NUMBER	=	79.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.134	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.260	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.320	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	57.584	INCHES
TOTAL INITIAL WATER	=	57.584	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.45	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.00	
START OF GROWING SEASON (JULIAN DATE)	=	98	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%

AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 74.00 %

NOTE: PRECIPITATION DATA FOR COLUMBIA MISSOURI
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.45 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1974

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.58	2.70	3.03	3.55	7.75	5.89
	1.43	7.57	1.77	1.20	3.81	1.65
RUNOFF	1.280	0.000	0.097	0.000	0.361	0.270
	0.000	0.044	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.624	1.531	2.423	3.280	5.772	6.536
	1.430	4.132	3.473	1.203	1.269	0.964
LATERAL DRAINAGE COLLECTED	1.3476	1.2126	2.1230	0.1922	0.0043	2.3782
FROM LAYER 2	0.0816	0.0000	1.0954	0.0352	0.1347	0.6379
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.036	0.009	0.023	0.001	0.000	0.056
TOP OF LAYER 3	0.001	0.000	0.007	0.000	0.001	0.004
STD. DEVIATION OF DAILY	0.167	0.006	0.061	0.001	0.000	0.246
HEAD ON TOP OF LAYER 3	0.001	0.000	0.008	0.000	0.002	0.003
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.93	159465.828	100.00

RUNOFF	2.052	7450.033	4.67
EVAPOTRANSPIRATION	32.636	118470.414	74.29
DRAINAGE COLLECTED FROM LAYER 2	9.2426	33550.746	21.04
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0115		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.009	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
DRAINAGE COLLECTED FROM LAYER 11	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 13	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 12	0.0000		
DRAINAGE COLLECTED FROM LAYER 15	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 16	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 16	0.0000		
CHANGE IN WATER STORAGE	-0.001	-5.290	0.00
SOIL WATER AT START OF YEAR	60.368	219134.937	
SOIL WATER AT END OF YEAR	60.366	219129.656	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.086	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1975

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.38	2.96	3.23	4.29	4.00	3.83
	0.55	8.18	5.60	2.06	3.57	2.48

RUNOFF	0.003	1.760	1.691	0.073	0.000	0.064
	0.000	0.652	0.056	0.000	0.054	0.051
EVAPOTRANSPIRATION	0.637	0.366	1.906	3.042	5.571	4.299
	0.560	3.888	4.502	1.623	1.413	0.720
LATERAL DRAINAGE COLLECTED	0.3487	0.0000	2.5661	1.7371	0.5893	0.0387
FROM LAYER 2	0.0000	0.2739	1.5024	0.3924	1.0627	1.4142
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.002	0.000	0.187	0.012	0.004	0.000
TOP OF LAYER 3	0.000	0.002	0.010	0.003	0.007	0.009
STD. DEVIATION OF DAILY	0.002	0.000	0.702	0.011	0.003	0.000
HEAD ON TOP OF LAYER 3	0.000	0.007	0.006	0.002	0.008	0.010
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000

STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.13	160191.891	100.00
RUNOFF	4.405	15988.702	9.98
EVAPOTRANSPIRATION	28.527	103551.758	64.64
DRAINAGE COLLECTED FROM LAYER 2	9.9256	36029.895	22.49
PERC./LEAKAGE THROUGH LAYER 4	0.000005	0.017	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0197		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.015	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
DRAINAGE COLLECTED FROM LAYER 11	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 13	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 12	0.0000		
DRAINAGE COLLECTED FROM LAYER 15	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 16	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 16	0.0000		
CHANGE IN WATER STORAGE	1.273	4621.566	2.89
SOIL WATER AT START OF YEAR	60.366	219129.656	
SOIL WATER AT END OF YEAR	60.893	221041.984	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.746	2709.233	1.69
ANNUAL WATER BUDGET BALANCE	0.0000	-0.047	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1976

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.94	2.36	4.39	2.21	3.68	1.79
	0.24	0.21	0.47	6.12	0.88	0.59
RUNOFF	0.248	0.000	0.008	0.000	0.000	0.000
	0.000	0.000	0.000	0.123	0.000	0.000
EVAPOTRANSPIRATION	0.741	1.354	2.527	3.335	4.510	2.192
	0.373	0.210	0.467	1.970	1.568	0.460
LATERAL DRAINAGE COLLECTED	1.7392	0.4017	2.1950	0.2396	0.0309	0.0007
FROM LAYER 2	0.0007	0.0000	0.0000	0.0313	1.4072	0.0795
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.078	0.003	0.054	0.002	0.000	0.000
TOP OF LAYER 3	0.000	0.000	0.000	0.000	0.009	0.001
STD. DEVIATION OF DAILY	0.288	0.001	0.186	0.001	0.000	0.000

HEAD ON TOP OF LAYER 3	0.000	0.000	0.000	0.000	0.010	0.001
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.88	86684.406	100.00
RUNOFF	0.378	1373.518	1.58
EVAPOTRANSPIRATION	19.706	71533.867	82.52
DRAINAGE COLLECTED FROM LAYER 2	6.1256	22236.041	25.65
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0123		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.009	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
DRAINAGE COLLECTED FROM LAYER 11	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 13	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 12	0.0000		
DRAINAGE COLLECTED FROM LAYER 15	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 16	0.000000	0.001	0.00

AVG. HEAD ON TOP OF LAYER 16	0.0000		
CHANGE IN WATER STORAGE	-2.330	-8459.001	-9.76
SOIL WATER AT START OF YEAR	60.893	221041.984	
SOIL WATER AT END OF YEAR	59.272	215157.406	
SNOW WATER AT START OF YEAR	0.746	2709.233	3.13
SNOW WATER AT END OF YEAR	0.037	134.817	0.16
ANNUAL WATER BUDGET BALANCE	0.0000	-0.030	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1977

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.44	1.17	3.70	2.52	4.49	5.24
	1.62	2.26	6.66	3.68	2.16	1.55
RUNOFF	0.060	0.000	0.038	0.005	0.066	0.000
	0.000	0.003	0.093	0.090	0.000	0.000
EVAPOTRANSPIRATION	0.353	0.920	2.299	3.473	4.977	3.434
	3.669	1.121	4.176	1.677	1.474	0.551
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.1593	0.6899	1.1785	0.7716	0.0415
	0.0000	0.0000	0.6002	1.8833	1.5122	0.1415
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.001	0.004	0.008	0.005	0.000
TOP OF LAYER 3	0.000	0.000	0.004	0.021	0.010	0.001
STD. DEVIATION OF DAILY	0.000	0.002	0.004	0.008	0.004	0.000
HEAD ON TOP OF LAYER 3	0.000	0.000	0.005	0.059	0.012	0.001
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	36.49	132458.672	100.00
RUNOFF	0.356	1290.820	0.97
EVAPOTRANSPIRATION	28.124	102088.617	77.07
DRAINAGE COLLECTED FROM LAYER 2	6.9782	25330.809	19.12
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0046		

DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.005	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
DRAINAGE COLLECTED FROM LAYER 11	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 13	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 12	0.0000		
DRAINAGE COLLECTED FROM LAYER 15	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 16	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 16	0.0000		
CHANGE IN WATER STORAGE	1.033	3748.492	2.83
SOIL WATER AT START OF YEAR	59.272	215157.406	
SOIL WATER AT END OF YEAR	60.342	219040.703	
SNOW WATER AT START OF YEAR	0.037	134.817	0.10
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.083	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.70	1.51	5.50	5.00	7.57	2.50
	4.56	2.01	1.06	1.78	3.24	1.64
RUNOFF	0.016	0.117	0.235	0.000	0.249	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.261	0.474	2.824	3.926	6.035	3.691
	4.577	1.346	1.475	1.494	1.319	0.901
LATERAL DRAINAGE COLLECTED	0.0000	0.7300	3.0814	1.8470	2.1086	0.1554
FROM LAYER 2	0.0000	0.0000	0.0001	0.0004	0.0002	0.7098

PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FROM LAYER 15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.005	0.042	0.012	0.049	0.001
TOP OF LAYER 3	0.000	0.000	0.000	0.000	0.000	0.005
STD. DEVIATION OF DAILY	0.000	0.008	0.148	0.008	0.224	0.001
HEAD ON TOP OF LAYER 3	0.000	0.000	0.000	0.000	0.000	0.005
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 12	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 16	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.07	134564.062	100.00
RUNOFF	0.617	2238.860	1.66
EVAPOTRANSPIRATION	28.324	102815.086	76.41
DRAINAGE COLLECTED FROM LAYER 2	8.6329	31337.410	23.29
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0095		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.006	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
DRAINAGE COLLECTED FROM LAYER 11	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 13	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 12	0.0000		
DRAINAGE COLLECTED FROM LAYER 15	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 16	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 16	0.0000		
CHANGE IN WATER STORAGE	-0.503	-1827.255	-1.36
SOIL WATER AT START OF YEAR	60.342	219040.703	
SOIL WATER AT END OF YEAR	59.838	217213.453	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.052	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.01	2.14	3.97	3.51	5.50	3.85
	1.68	4.05	3.11	2.97	2.73	1.58
STD. DEVIATIONS	1.37	0.77	1.00	1.17	2.00	1.74
	1.71	3.59	2.82	1.99	1.21	0.67
RUNOFF						
TOTALS	0.321	0.375	0.414	0.016	0.135	0.067
	0.000	0.140	0.030	0.043	0.011	0.010
STD. DEVIATIONS	0.545	0.776	0.719	0.032	0.162	0.117
	0.000	0.287	0.043	0.059	0.024	0.023
EVAPOTRANSPIRATION						
TOTALS	0.523	0.929	2.396	3.411	5.373	4.030
	2.122	2.139	2.819	1.593	1.409	0.719
STD. DEVIATIONS	0.205	0.517	0.336	0.327	0.620	1.597
	1.897	1.762	1.764	0.279	0.120	0.217
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.6871	0.5007	2.1311	1.0389	0.7010	0.5229
	0.0165	0.0548	0.6396	0.4685	0.8234	0.5966
STD. DEVIATIONS	0.8065	0.4838	0.8907	0.7931	0.8563	1.0388
	0.0364	0.1225	0.6655	0.8071	0.7115	0.5379
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 13

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 15

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 16

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0234	0.0036	0.0623	0.0069	0.0116	0.0114
	0.0001	0.0004	0.0043	0.0048	0.0055	0.0039
STD. DEVIATIONS	0.0344	0.0035	0.0725	0.0053	0.0210	0.0247
	0.0002	0.0008	0.0044	0.0092	0.0047	0.0035

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 12

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 16

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	37.10	(8.234)	134673.0	100.00
RUNOFF	1.562	(1.7371)	5668.39	4.209
EVAPOTRANSPIRATION	27.463	(4.7233)	99691.95	74.025
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.18099	(1.58478)	29696.980	22.05118
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.010	0.00001
AVERAGE HEAD ON TOP OF LAYER 3	0.011	(0.005)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00000	(0.00000)	0.009	0.00001
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.002	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 11	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.00000	(0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP	0.000	(0.000)		

OF LAYER 12

LATERAL DRAINAGE COLLECTED FROM LAYER 15	0.00000 (	0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 16	0.00000 (	0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP OF LAYER 16	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.106 (	1.4418)	-384.30	-0.285

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	3.80	13794.000
RUNOFF	1.222	4435.3569
DRAINAGE COLLECTED FROM LAYER 2	1.03744	3765.91748
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000001	0.00518
AVERAGE HEAD ON TOP OF LAYER 3	2.912	
MAXIMUM HEAD ON TOP OF LAYER 3	4.378	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	31.8 FEET	
DRAINAGE COLLECTED FROM LAYER 8	0.00000	0.00423
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 9	0.000	
MAXIMUM HEAD ON TOP OF LAYER 9	0.043	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 11	0.00000	0.00003
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 12	0.000	

MAXIMUM HEAD ON TOP OF LAYER 12	0.004	
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 15	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 16	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 16	0.000	
MAXIMUM HEAD ON TOP OF LAYER 16	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 15 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.64	9588.3516

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3829
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1160

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	5.7292	0.2387
2	0.0052	0.0210
3	0.0000	0.0000
4	0.1875	0.7500
5	0.2700	0.0450
6	38.9760	0.2320

7	0.8100	0.0450
8	0.0025	0.0100
9	0.0000	0.0000
10	2.7840	0.2320
11	0.0025	0.0100
12	0.0000	0.0000
13	0.1875	0.7500
14	1.3920	0.2320
15	1.1520	0.0320
16	5.5560	0.4630
SNOW WATER	0.000	

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ATTACHMENT 5

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR GEOSYNTHETIC (SECTION 2.0: GEOMEMBRANES)

2.1 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geomembrane material, the Manufacturer or Installer shall provide the Construction Manager with the following information:

1. The origin (resin suppliers name and resin production plant), identification (brand name and number), and production date of the resin.
2. Copies of the quality control certificates issued by the resin supplier.
3. Reports on tests conducted by the Manufacturer to verify that the quality of the resin used to manufacture the geomembrane meets the Specifications.
4. Reports on quality control tests conducted by the Manufacturer to verify that the geomembrane manufactured for the project meets the project specifications.
5. A statement indicating that no reclaimed polymer was added to the resin during manufacturing.
6. A list of the materials with which comprise the geomembrane, expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.
7. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.
8. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, sampling procedures, and results of quality control tests. At a minimum, results shall be for:

   a. Density
   b. Carbon black content
   c. Carbon black dispersion
   d. Thickness
   e. Tensile properties
   f. Tear resistance

These quality control tests shall be performed in accordance with the frequency and test methods in the Specifications.

The Manufacturer shall identify all rolls of geomembranes with the following:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Roll number
5. Roll dimensions

The Geosynthetic CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Construction Manager. The Geosynthetic CQA Consultant shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed performance criteria. Measurements of properties by the Manufacturer are properly documented and that test methods used are acceptable.
2. Quality control certificates have been provided at the specified frequency for all rolls and that each certificate identifies the rolls related to it.
3. Rolls are appropriately labeled.
4. Certified minimum properties meet the requirement of the Specifications.

2.2 CONFORMANCE TESTING

Upon delivery of the rolls of geomembrane, the Geosynthetic CQA Consultant shall ensure conformance test samples are obtained for the geomembrane. These samples shall be that forwarded to the Geosynthetic QAL for testing to ensure conformance to the Specifications. If the Construction Manager desires, the Geosynthetic CQA Consultant can direct the conformance sampling be completed at the manufacturing plant.

The following conformance tests shall be conducted:

1. Density
2. Carbon black content
3. Carbon black dispersion
4. Thickness
5. Tensile characteristics
6. Asperity height
7. Interface friction between textured geomembrane/geosynthetic clay liner, textured geomembrane/ geonet, smooth geomembrane/geonet, and smooth geomembrane/soil.

These conformance tests shall be performed in accordance with the test frequency and methods in the Specifications.

2.2.1 Sampling Procedures

The rolls to be sampled shall be selected by the Geosynthetic CQA Consultant. Samples shall be taken across the entire width of the roll and shall not include the first 3 ft (1 m). Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Consultant shall mark the machine direction on the samples with an arrow.
A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic CQA Consultant based on a review of all roll information including quality control documentation manufacturing records.

2.2.2 Liner System Shear Box Testing

Prior to acceptance by the Geosynthetic CQA Consultant or the Construction Manager, the Contractor shall submit information documenting the interface friction values of the selected geosynthetics. Interface friction values shall be determined for the selected material combination provided by the Specifications. Interface friction data shall be submitted by the Contractor for review and approval within 30 days of contract award.

The Construction Manager will review the documentation for conformance with the requirements of the design. This conformance test shall be performed in accordance with the requirements of the Specifications as per ASTM D 5321.

2.2.3 Test Results

All conformance test results shall be reviewed and by the Geosynthetic CQA Consultant prior to the deployment of the geomembrane. The Geosynthetic CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Construction Manager. The Geosynthetic CQA Consultant shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications. Based upon the recommendation of the Geosynthetic CQA Consultant, the Construction Manager shall accept or reject the geomembrane.

If the Manufacturer has reason to believe that failing tests may be the result of Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. This retesting shall be done at the expense of the Manufacturer. Alternatively, the Manufacturer may have the sample retested at two different Solutia approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to approval of the Construction Manager.

If a test result is in nonconformance, all material from the lot represented by the failed test should be considered out of specification and rejected. Alternatively, at the option of the Construction Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specifications (note that this procedure is valid only when rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out of specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

2.3 SUBGRADE PREPARATION

2.3.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing the supporting soil for geomembrane placement. The Construction Manager shall coordinate the work of the Earthwork Contractor and the Installer so that the requirements of the Specifications and the project CQA Manual are met.

Before the geomembrane installation begins, the Geosynthetic CQA Consultant shall verify that:

1. A qualified land surveyor has verified all lines and grades.
2. A qualified geotechnical engineer has verified that the supporting soil meets the density specified in the project specifications.
3. The surface to be lined has been rolled, compacted, or handworked so as to be free irregularities, protrusions, loose soil and abrupt changes in grade. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system.
4. The surface of the supporting soil does not contain stones which may be damaging the geomembrane.
5. There is no area excessively softened by high water content.
6. There is no area where the surface of the soil contains desiccation cracks with dimensions exceeding those allowed by the Specifications.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. A certificate of acceptance shall be given by the Installer to the Geosynthetic CQA Consultant and Construction Manager prior to commencement of geomembrane deployment in the area under consideration.

After the supporting soil has been accepted by the Installer, it is the Installer's responsibility to indicate to the Construction Manager any change in the supporting soil condition that may require repair work. The Construction Manager may consult with the Geosynthetic CQA Consultant regarding the need for repairs. The Construction Manager shall ensure that the supporting soil is repaired.

At any time before or during the geomembrane installation, the Geosynthetic CQA Consultant shall indicate to the Construction Manager any locations which may not be adequately prepared for the geomembrane.

2.3.2 Anchor Trench

The Geosynthetic CQA Consultant shall verify that the anchor trench has been constructed according to the design Plans and Specifications.

If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of trench open at any time should be minimized. The Geosynthetic CQA Consultant shall inform the Construction Manager of any signs of significant desiccation associated with the anchor trench construction.

Slightly rounded corners shall be provided in the trench so as to avoid sharp bends in the geomembrane. Excessive amounts of loose soil shall not be allowed to underlie geomembrane in the anchor trench.

The anchor trench shall be adequately drained to prevent ponding or softening of adjacent sods while the trench is open. The anchor trench shall be backfilled and compacted as outlined in the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to geosynthetics. The Geosynthetic CQA Consultant shall observe the backfilling operation and advise the Construction Manager of any problems. Any problems shall be documented by the Geosynthetic CQA Consultant in his daily report.

2.4 GEOMEMBRANE DEPLOYMENT

2.4.1 Panel Nomenclature

A field panel is defined as a unit of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll cut in the field.

It shall be the responsibility of the Geosynthetic CQA Consultant to ensure that each field panel be given an identification code (number or letter-number) consistent with the layout plan. This identification code shall be agreed upon by the Construction Manager, Installer and Geosynthetic CQA Consultant. This field panel identification code shall be as simple and logical as possible. In general, it is not appropriate to identify panels using roll numbers since numbers established in the manufacturing plant are usually cumbersome and are related to location in the field. The Geosynthetic CQA Consultant shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

The Geosynthetic CQA Consultant shall verify that field panels are installed at the locations indicated on the Installer's layout plan, as approved by the Construction Manager.

2.4.2 Panel Deployment Procedure

The Geosynthetic CQA Consultant shall review the panel deployment progress of the Installer (keeping in mind issues relating to wind, rain, clay liner desiccation, and other site-specific conditions) and advise the Construction Manager on its compliance with the approved panel layout drawing and its suitability to the actual field conditions. Once approved, only the Construction Manager can authorize changes to the panel deployment procedure. Geosynthetic CQA Consultant shall verify that the condition of the supporting soil does not change detrimentally during installation.

The Geosynthetic CQA Consultant shall record the identification code, location, and date of installation of each field panel.

2.4.3 Deployment Weather Conditions

Geomembrane deployment shall not proceed at an ambient temperature below 32° F (0° C) or above 104° F (40° C) unless otherwise authorized, in writing, by the Construction Manager. Geomembrane placement shall not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds. Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment.

The Geosynthetic CQA Consultant shall verify that the above conditions are fulfilled. Ambient temperature shall be measured by the Geosynthetic CQA Consultant in the area in which the panels are to be deployed. The Geosynthetic CQA Consultant shall inform the Construction Manager of any weather related problems which may not allow geomembrane placement to proceed.

2.4.4 Method of Deployment

Before the geomembrane is handled on site, the Geosynthetic CQA Consultant shall verify that handling equipment to be used on the site is adequate and does not pose risk of damage to the geomembrane. During handling, the Geosynthetic CQA Consultant shall observe and verify that the Installer's personnel handle the geomembrane with care.

The Geosynthetic CQA Consultant shall verify the following:

1. Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.
2. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement.
3. Any geosynthetic elements immediately underlying the geomembrane are clean and free of debris.
4. All personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities which could damage the geomembrane.

5. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil. Rolls of geomembrane shall be deployed down a side slope in a controlled manner. Geomembrane shall not be pulled up the side slope.

6. The method used to place the panels minimized wrinkles (especially differential wrinkles between adjacent panels).

7. Adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind. In case of winds, continuous loading, e.g., by sand bags, is recommended along edges of panel to minimize risk of wind flow under the panels.

8. Direct contact with the geomembrane is minimized, and the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

The Geosynthetic CQA Consultant shall inform the Construction Manager if the above conditions are not fulfilled.

2.4.5 Damage and Effects

Upon delivery to the site, the Geosynthetic CQA Consultant shall conduct a surface observation of all rolls for defects and for damage. This inspection shall be conducted without unrolling rolls unless defects or damages are found or suspected. The Geosynthetic CQA Consultant shall advise the Construction Manager, in writing, of any rolls or portions of rolls which should be rejected and removed from the site because they have severe flaws, and/or minor repairable flaws.

The Geosynthetic CQA Consultant shall inspect each panel, after placement and prior to seaming, for damage and/or defects. The Geosynthetic CQA Consultant shall advise the Construction Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the Geosynthetic CQA Consultant. Repairs shall be made using procedures described in the Specifications.

2.4.6 Writing on the Liner

To avoid confusion, the Installer and the Geosynthetic CQA Consultant shall each use different colored markers that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane. The installer shall use a yellow marker to write on the geomembrane. The Geosynthetic CQA Consultant shall use a red marker.

2.5 FIELD SEAMING

2.5.1 Seam Layout

Before installation begins, the Installer must provide the Construction Manager and the Geosynthetic CQA Consultant with a panel layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The Geosynthetic CQA Consultant shall review the panel layout drawing and verify that it is consistent with accepted state-of-practice. No panels may be seamed without written approval of the panel layout drawing by the Construction Manager. In addition, panels not specifically shown on the panel layout drawing may not be used without the Construction Manager's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized by the Construction Manager.

A seam numbering system compatible with the panel numbering system shall be used by the Geosynthetic CQA Consultant.

2.5.2 Accepted Seaming Methods

Approved processes for field seaming are extrusion welding and fusion welding. Fusion double seam welding is the preferred method for joining long, straight seams. Extrusion welding is the preferred seaming method in areas such as corners, sumps, pipe penetrations, tear repairs and cap strips where fusion double seam welding is not feasible. Use of extrusion welding shall be minimized to the extent possible. Proposed alternate processes shall be documented and submitted by the Installer to the Construction Manager for approval. Only apparatus which have been specifically approved by make and model shall be used. The Construction Manager shall submit all documentation regarding seaming methods to be used to the Geosynthetic CQA Consultant for review.

2.5.2.1 Extrusion Process

The Geosynthetic CQA Consultant shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the construction manager.

The Geosynthetic CQA Consultant shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus decided upon at the pre-construction meeting.
2. Equipment used for seaming is not likely to damage the geomembrane.
3. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.

4. Clean and dry welding rods or extrudate pellets are used.
5. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.
6. Grinding shall be completed no more than 1 hour prior to seaming.
7. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage.
8. The geomembrane is protected from damage in heavily trafficked areas.
9. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend more than ¼-inch from the seamed area.
10. In general, the geomembrane panels are aligned to have a nominal overlap of 3 inches (75 mm) for extrusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.
11. No solvent or adhesive is used unless the product is approved in writing by the construction manager prior to use (samples shall be submitted to the construction manager for testing and evaluation).
12. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged or degraded.

2.5.2.2 Fusion Process

The Geosynthetic CQA Consultant shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the construction manager.

The Geosynthetic CQA Consultant shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus decided upon at the pre-construction meeting.
2. Equipment used for seaming is not likely to damage the geomembrane.
3. For cross seams, the edge of the cross seam is ground to an incline prior to welding.
4. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.
5. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage.
6. The geomembrane is protected from damage in heavily trafficked areas.
7. A movable protective layer is used as required by the installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and prevent debris from collecting around the pressure rollers.

8. In general, the geomembrane panels are aligned to have a nominal overlap of 5 inches (125 mm) for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.
9. No solvent or adhesive is used unless the product is approved in writing by the Construction Manager prior to use (samples shall be submitted to the Construction Manager for testing and evaluation).

2.5.3 Seam Preparation

The Geosynthetic CQA Consultant shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the Geosynthetic CQA Consultant must ensure that the process is completed according to the manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane. The Geosynthetic CQA Consultant shall also verify that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

2.5.4 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours, for each production seaming apparatus used that day. Each seamer shall make at least one trial seam each day. Trial seams shall be made under the same conditions as actual seams.

The trial seam sample shall be at least 5 ft (1.0 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section 4.6.2.

Two specimens shall be cut from the sample with a 1-inch (25 mm) wide die. The specimens shall be cut by the installer at locations selected randomly along the trial seam sample by the Geosynthetic CQA Consultant. The specimens shall be tested in peel using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. They should not fail in the seam. If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial welds are achieved. The Geosynthetic CQA Consultant shall observe all trial seam procedures.

The remainder of the successful trial seam sample shall be cut into three pieces, one to be retained in the construction manager's archives, one to be given to the installer, and one to be retained by the Geosynthetic CQA Consultant for possible laboratory testing. Each portion of the sample shall be assigned a number and marked accordingly by the Geosynthetic CQA Consultant, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

If agreed upon between the Construction Manager and the Geosynthetic CQA Consultant, and documented by the Geosynthetic CQA Consultant in his/her daily report, the remaining portion of the trial seam sample can be subjected to destructive testing. If a trial seam sample fails a test conducted by the Geosynthetic QAL, then a destructive seam test sample shall be taken from each of the seams completed by the seamer during the shift related to the considered trial seam. These samples shall be forwarded to the Geosynthetic QAL and, if they fail the tests, the seam shall be subjected to the "Destructive Test Failure Procedures" identified in this CQA Manual. The conditions of this paragraph shall be considered satisfied for a given seam if a destructive seam test sample has already been taken.

2.5.5 General Seaming Procedures

During general seaming, the Geosynthetic CQA Consultant shall be cognizant of the following:

1. For fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture buildup between the sheets to be welded and prevent debris from collecting around the pressure rollers.
2. If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.
3. Fishmouths or wrinkles at the scam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches (150 mm) beyond the cut in all directions.
4. If seaming operations are carried out at night, adequate illumination shall be provided.
5. Seaming shall extend to the outside edge of panels placed in the anchor trench.
6. All cross seam tees should be extrusion welded to a minimum distance of 4 inches on each side of the tee.
7. No field seaming shall take place without the master seamer being present.

The Geosynthetic CQA Consultant shall verify that the approved seaming procedures are followed, and shall inform the Construction Manager of any nonconformance.

2.5.6 Seaming Weather Conditions

2.5.6.1 Normal Weather Conditions

The normal required weather conditions for seaming are as follows:

1. Ambient temperature between 32° F (0° C) and 104° F (40° C).
2. Dry conditions (i.e., no precipitation or other excessive moisture, such as fog or dew).
3. No excessive winds.

The Geosynthetic CQA Consultant shall verify that these weather conditions are fulfilled and notify the Construction Manager in writing if they are not. Ambient temperature shall be measured by the Geosynthetic CQA Consultant in the area in which the panels are to be placed. The Construction Manager will then decide if the installation is to be stopped or special procedures used.

2.5.6.2 Cold Weather Conditions

To ensure a quality installation, if seaming is conducted when the ambient temperature is below 32° F (0° C), the following conditions must be met:

1. Geomembrane surface temperatures shall be determined by the Geosynthetic CQA Consultant at intervals of at least once per 100 foot of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32° F (0° C).
2. Preheating may be waived by the construction manager based on a recommendation from the Geosynthetic CQA Consultant, if the installer demonstrates to the Geosynthetic CQA Consultant's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.
3. If preheating is required, the Geosynthetic CQA Consultant shall inspect all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.
4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.
5. All preheating devices shall be approved prior to use by the construction manager.
6. Additional destructive tests shall be taken at an interval between 500 and 250 feet of seam length, at the discretion of the Geosynthetic CQA Consultant.
7. Sheet grinding may be performed before preheating, if applicable.
8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the actual seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 5° F from the initial trial seam test conditions.

2.5.6.3 Warm Weather Conditions

At ambient temperatures above 104° F, no seaming of the geomembrane shall be permitted unless the installer can demonstrate to the satisfaction of the construction manager that geomembrane seam quality is not compromised.

Trial seaming shall be conducted under the same ambient temperature conditions as the actual seams.

At the option of the Geosynthetic CQA Consultant, additional destructive tests may be required for any suspect areas.

2.6 NONDESTRUCTIVE SEAM TESTING

2.6.1 Concept

The Installer shall nondestructively test all field seams over their full length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantitative information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

For all seams, the Geosynthetic CQA Consultant shall:

1. Observe nondestructive testing procedures.
2. Record location, data, test unit number, name of tester, and outcome of all testing.
3. Inform the Installer and Construction Manager of any required repairs.

Any seam that cannot be nondestructively tested shall be cap-stripped with the same geomembrane. The cap-stripping operations shall be observed by the Geosynthetic CQA Consultant and Installer for uniformity and completeness.

2.6.2 Vacuum Testing

The following procedures are applicable to vacuum testing.

1. The equipment shall consist of the following:
    a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.
    b. A pump assembly equipped with a pressure controller and pipe connections.
    c. A rubber pressure/vacuum hose with fittings and connections.
    d. A soapy solution.
    e. A bucket and wide paint brush, or other means of applying the soapy solution.
2. The following procedures shall be followed:
    a. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi (10 in. of Hg) (35 kPa) gauge.
    b. Wet a strip of geomembrane approximately 12 inches x 48 inches (0.3 m x 1.2 m) with the soapy solution.

c. Place the box over the wetted area.

d. Close the bleed valve and open the vacuum valve.

e. Ensure that a leak-tight seal is created.

f. For a period of not less than 10 seconds, apply vacuum and examine the geomembrane through the viewing window for the presence of soap bubbles.

g. If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches (75 mm) overlap, and repeat the process.

h. All areas where soap bubbles appear shall be marked and repaired.

2.6.3 Air Pressure Testing

The following procedures are applicable to double fusion welding which produces a double seam with an enclosed space.

1. The equipment shall consist of the following:

    a. An air pump (manual or motor driven), equipped with pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi (160 and 200 kPa) and mounted on a cushion to protect the geomembrane.

    b. A rubber hose with fittings and connections.

    c. A sharp hollow needle, or other approved pressure feed device.

2. The following procedures shall be followed:

    a. Seal both ends of the seam to be tested.

    b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.

    c. Insert a protective cushion between the air pump and the geomembrane.

    d. Energize the air pump to a pressure between 25 and 30 psi (160 and 200 kPa), close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for at least 5 minutes.

    e. If loss of pressure exceeds 4 psi (30 kPa) or does not stabilize, locate faulty area and repair in accordance with Section 4.9.3.

    f. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seal the cut end of the air channel.

    g. Remove needle or other approved pressure feed device and seal.

2.6.4 Test Failure Procedure

The Installer shall complete any required repairs in accordance with the requirements of the Specifications. For repairs, the Geosynthetic CQA Consultant shall:

1. Observe the repair and testing of the repair.
2. Mark on the geomembrane that the repair has been made.
3. Document the repair procedures and test results.

2.7 DESTRUCTIVE SEAM TESTING

2.7.1 Concept

Destructive seam tests shall be performed at selected locations in accordance with the requirements of the Specifications. The purpose of these tests is to evaluate seam strength. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

2.7.2 Location and Frequency

The Geosynthetic CQA Consultant shall select locations where seam samples will be cut out for laboratory testing. Those locations shall be established as follows:

1. A minimum frequency of one test location per 500 ft (150 m) of seam length performed by each welder. This minimum frequency is to be determined as an average taken throughout the entire facility.
2. Test locations shall be determined during seaming at the Geosynthetic CQA Consultant's discretion. Selection of such locations may be prompted by suspicion of overheating, contamination, offset welds, or any other potential cause of imperfect welding.
3. One additional CQA destructive seam test will be performed for every 10 destructive tests required by the specifications with a minimum of two CQA destructive tests per geomembrane layer.

The Installer shall not be informed in advance of the locations where the seam samples will be taken.

2.7.3 Sampling Procedures

Samples shall be cut by the Installer at locations chosen by the Geosynthetic CQA Consultant as the seaming progresses so that laboratory test results are available before the geomembrane is covered by another material. The Geosynthetic CQA Consultant shall:

1. Observe sample cutting.
2. Assign a number to each sample, and mark it accordingly.

3. Record sample location on layout drawing.
4. Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in the Specification. The continuity of the new seams in the repaired area shall be tested.

2.7.4 Sample Dimensions

At a given sampling location, two types of samples shall be taken by the Installer. First, two samples for field testing should be taken. Each of these samples shall be cut with a 1-inch (25 mm) wide die, with the seam centered parallel to the width. The distance between these two samples shall be 42 inches (1.1 m). If both samples pass the field test described in Section 4.8.5, a sample for laboratory testing shall be taken.

The sample for laboratory testing shall be located between the samples for field testing. The sample for laboratory testing shall be 12 inches (0.3 m) wide by 42 inches (1.1 m) long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

1. One portion to the Installer for optional laboratory testing, 12 inches x 12 inches (0.3 m x 0.3 m)
2. One portion for Geosynthetic QAL testing, 12 inches x 18 inches (0.3 m x 0.5 m) and
3. One portion to the Construction Manager for archive storage, 12 inches x 12 inches (0.3 m x 0.3 m).

Final determination of the sample sizes shall be made at the pre-construction meeting.

2.7.5 Field Testing

The two 1-inch (25 mm) wide strips shall be tested in the field using a tensiometer for peel and shall not fail according to the criteria in the Specifications. The tensiometer shall be capable of maintaining a constant jaw separation rate of 2 in. per minute. If the test passes in accordance with this section, the sample qualifies for testing in the laboratory. If it fails, the seam should be repaired. Final judgement regarding seam acceptability, based on the failure criteria shall be made by the Construction Manager.

The Geosynthetic CQA Consultant shall witness all field tests and mark all samples and portions with their number. The Geosynthetic CQA Consultant shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description, and attach a copy to each sample portion.

2.7.6 Laboratory Testing

Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the Geosynthetic CQA Consultant in a manner which will not damage the test sample. The Construction Manager will be responsible for storing the archive samples. Test samples shall be tested by the Geosynthetic QAL.

Testing shall include "seam strength" and "peel adhesion". These terms are defined in the specifications. The minimum acceptable values to be obtained in these tests are indicated in the Specifications. At least 5 specimens shall be tested in each shear and peel. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A passing test shall meet the minimum acceptable values in at least 4 of the 5 specimens tested for each method.

The Geosynthetic QAL shall provide verbal test results no more than 24 hours after they receive the samples. The Geosynthetic CQA Consultant shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Construction Manager.

2.7.7 Destructive Test Failure Procedures

The following procedures shall apply whenever a sample fails a destructive test, whether that test is conducted by the Geosynthetic QAL, or by field tensiometer. The Installer has two options:

1. The Installer can repair the seam between any two passing test locations.
2. The Installer can trace the welding path to an intermediate location (at 10 ft (3 m) minimum from the point of the failed test in each direction) and take a sample with a 1 in. (25 mm) wide die for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is repaired between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be repaired.

All acceptable repaired seams shall be bound by two locations from which samples passing laboratory destructive tests have been taken. Passing laboratory destructive tests of trial seam samples taken as indicated in Section 4.6.4 may be used as a boundary for the failing seam. In cases exceeding 150 ft (50 m) of repaired seam, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Repairs shall be made in accordance with Specifications.

The Geosynthetic CQA Consultant shall document all actions taken in conjunction with destructive test failures.

2.8 DEFECTS AND REPAIRS

2.8.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the Geosynthetic CQA Consultant for identification of defects, holes, busters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be cleaned by the installer if the amount of dust or mud inhibits examination.

2.8.2 Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in the Specifications as appropriate. Each location which fails the nondestructive testing shall be marked by the Geosynthetic CQA Consultant and repaired by the installer. Work shall not proceed with any materials which will cover locations which have been repaired until appropriate nondestructive and laboratory test results with passing values are available.

2.8.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Construction Manager, Installer, and Geosynthetic CQA Consultant.

1. The repair procedures available include:

    a. Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.

    b. Spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws.

    c. Capping, used to repair large lengths of failed seams.

    d. Extrusion welding the flap, used to repair areas of inadequate fusion seams, which have an exposed edge. Repairs of this type shall be approved by the Geosynthetic CQA Consultant, and shall not exceed 50 ft (15 m) in length.

    e. Removing bad seam and replacing with a strip of new material welded into place.

2. For any repair method, the following provisions shall be satisfied:

    a. Surfaces of the geomembrane which are to be repaired using extrusion methods shall be abraded no more than one hour prior to the repair.

    b. All surfaces shall be clean and dry at the time of the repair.

    c. All seaming equipment used in repairing procedures shall meet the requirements of the project CQA Manual.

    d. Patches or caps shall extend at least 6 inches (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches (75 mm).

2.8.4 Repair Verification

Each repair shall be numbered and logged. Each repair shall be nondestructively tested using the methods described in the Specifications as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 150 ft long may be of sufficient extent to require destructive test sampling, at the discretion of the Geosynthetic CQA Consultant. Failed tests indicate that the repair shall be redone and retested until a passing test results. The Geosynthetic CQA Consultant shall observe all nondestructive testing of repairs and shall record the number of each repair, date, and test outcome.

2.8.5 Large Wrinkles

When seaming of the geomembrane is completed, and prior to placing overlying materials, the Geosynthetic CQA Consultant shall indicate to the Construction Manager which wrinkles should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be, kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation process, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. The geomembrane will be inspected for wrinkles every morning by the Geosynthetic CQA Consultant and the results of the inspection will be documented. On completion of geomembrane installation, it will be inspected for wrinkles by the Geosynthetic CQA Consultant and the Agency and the results of this inspection will be video recorded with a date stamp. Unacceptably large wrinkles will be removed after this final inspection. Wrinkles are considered to be large when the geomembrane can be folded over on to itself. Seams produced while repairing wrinkles shall be tested as outlined above.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic CQA Consultant to ensure that wrinkle formation is minimized.

2.9 GEOMEMBRANE PROTECTION

The quality assurance procedures indicated in this section are intended only to assure that the installation of adjacent materials does not damage the geomembrane. The quality assurance of the adjacent materials themselves should be covered in separate sections of the project CQA Manual as necessary.

2.9.1 Soils

A copy of the specifications prepared by the designer for placement of soils shall be given to the Geosynthetic CQA Consultant by the Construction Manager. The Geosynthetic CQA Consultant shall verify that these specifications are consistent with the state-of-practice such as:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32° F (0° C) nor above 104° F (40° C) unless otherwise specified.

2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.
3. A geotextile or other cushion approved by the designer is generally required between aggregate and the geomembrane.
4. Equipment used for placing soil shall not be driven directly on the geomembrane.
5. A minimum thickness of 1 ft (0.3 m) of soil is specified between a light dozer (ground pressure of 5 psi (35 kPa) or lighter) and the geomembrane.
6. In any areas traversed by any vehicles other than low ground pressure vehicles approved by the Construction Manager, the soil layer shall have a minimum thickness of 3 ft (0.9 m). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

The Geosynthetic CQA Consultant shall measure soil thickness and verify that the required thicknesses are present. The Geosynthetic CQA Consultant must also verify that final thicknesses are consistent with the design and verify that placement of the soil is done in such a manner that geomembrane damage is unlikely. The Geosynthetic CQA Consultant shall inform the Construction Manager if the above conditions are not fulfilled.

ATTACHMENT 6

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR GEOSYNTHETIC (SECTION 6.0: GEOSYNTHETIC CLAY LINER)

6.1 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geosynthetic clay liner (GCL), the Manufacturer or Installer shall provide the Construction Manager with the following information:

1. The origin (supplier's name and production plant), identification (brand name and number), and production date.
2. Copies of the quality control certificates issued by the supplier.
3. Reports on tests conducted by the Manufacturer to verify that the quality used to manufacture the GCL meets the Specifications.
4. Reports on quality control tests conducted by the Manufacturer to verify that the GCL manufactured for the project meets the project specifications.
5. A specification for the GCL which includes all properties contained in the Specifications measured using the appropriate test methods.
6. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.
7. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control tests. At a minimum, results shall be given for:

    a. Swell Index
    b. Mass per unit area
    c. Thickness
    d. Grab Tensile Strength
    e. Permeability

    Quality control tests shall be performed in accordance with the frequency and test methods identified in the Specifications.

The Manufacturer shall identify all rolls of GCLs with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic CQA Consultant shall review these documents and shall report any discrepancies with the above requirements to the Construction Manager. The Geosynthetic CQA Consultant shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.
2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.
3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.
4. Roll packages are appropriately labeled.
5. Certified minimum properties meet the Specifications.

6.2 CONFORMANCE TESTING

Upon delivery of the rolls of GCL, the Geosynthetic CQA Consultant shall ensure that conformance test samples are obtained for the GCL. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance to the Specifications.

At a minimum, the following tests shall be performed:

1. Swell Index
2. Mass per unit area
3. Thickness
4. Permeability
5. Interface friction between geosynthetic clay liner/soil as well as the textured geomembrane/geosynthetic clay liner conformance test identified in Section 2.2.
6. Internal friction angle of the Geosynthetic Clay Liner materials after delivery to the site.

These conformance tests shall be performed in accordance with the test methods specified in the Solutia specifications. Other conformance tests required by the project specifications or the CQA manual shall be performed.

6.2.1 Sampling Procedures

The rolls to be sampled shall be selected by the Geosynthetic CQA Consultant. Samples shall be taken across the entire width of the roll and shall not include the first 3 ft (1 m). Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic CQA Consultant shall mark the machine direction on the samples with an arrow.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic CQA Consultant based on a review of all roll information including quality control documentation and manufacturing records.

6.2.2 Test Results

All conformance test results shall be reviewed and by the Geosynthetic CQA Consultant prior to the deployment of the GCL. The Geosynthetic CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the Construction Manager. The Geosynthetic CQA Consultant shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications. Based upon the recommendations of the Geosynthetic CQA Consultant the Construction Manger will accept or reject the GCL.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. This retesting shall be done at the expense of the Manufacturer. Alternatively, the Manufacturer may have the sample retested at two different Solutia approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Construction Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out of specification and rejected. Alternatively, at the option of the Construction Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out of specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

6.3 GCL DEPLOYMENT

The Geosynthetic CQA Consultant shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Construction Manager. The Geosynthetic CQA Consultant shall verify that rolls of GCL are not stored on the ground prior to installation.

The Installer shall handle all GCL in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with:

1. On slopes, the GCL shall be secured and rolled down the slope in such a manner as to continually keep the GCL sheet in tension. If necessary, the GCL shall be positioned by hand after being unrolled to minimize wrinkles.

2. In the presence of wind, all GCL shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.
3. Unless otherwise specified, GCL shall not be welded to geomembrane.
4. GCL shall only be cut using scissors or other cutting tools approved by the Construction Manager that will not damage the underlying geosynthetics. Care shall be taken not to leave tools in the GCL.
5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the GCL.
6. During placement of GCL, care shall be taken not to entrap dirt or excessive dust that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. In this regard, care shall be taken with the handling of sandbags, to prevent rupture or damage of the sandbag.
7. All GCL deployed in a given day must be covered with either a geomembrane or 12 inches of approved soil cover.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

6.4 SEAMS AND OVERLAPS

Adjacent GCL shall be joined according to construction drawings and specifications. At a minimum, the following requirements shall be met:

1. Adjacent rolls shall be overlapped by at least 6 inches (150 mm).
2. In general, no horizontal seams shall be allowed on side slopes.
3. In the corners of the side slopes of rectangular landfills, where overlaps between perpendicular GCL strips are required, an extra layer of GCL shall be unrolled along the slope, on top of the previously installed GCL, from top to bottom of the slope.
4. When more than one layer of GCL is installed, joints shall be staggered.

The Geosynthetic CQA Consultant shall note any noncompliance and report it to the Construction Manager.

6.5 DEFECTS AND REPAIRS

Any holes or tears in the GCL shall be repaired by placing a patch extending 1 ft (0.3 m) beyond the edges of the hole or tear. If the hole or tear width across the roll is more than 50% of the width of the roll, the damaged area shall be repaired as follows:

1. On the base of the landfill, the damaged area shall be cut out and the two portions of the GCL shall be joined as indicated in the Specifications.

2. On sideslopes, the damaged GCL shall be removed and replaced.

The Geosynthetic CQA Consultant shall observe any repair and report any noncompliance with the above requirements in writing to the Construction Manager.

ATTACHMENT 7

DESIGN REPORT (APPENDIX D: COVER SYSTEM COMPONENT DESIGN

Waste Consolidation

Purpose: Estimate Cover settlement due to waste consolidation

Configuration: Max. Waste thickness = 16'
Cover Soil thickness = 2'

Assumptions: Waste material is a sandy silt soil
Liquid Limit is less than 40
Material will be dried to meet paint filter req'mts
Material will be compacted to some degree in place

Calculations: Since actual consolidation parameters for waste are unavailable, use correlations to estimate parameters

For remolded clays: $C_c = 0.007(LL-7)$
$= 0.007(40-7)$
$= \underline{0.23}$

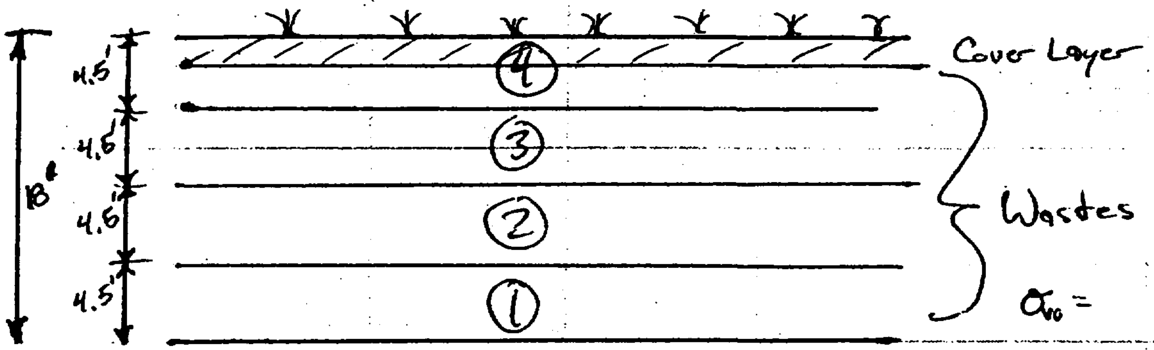
Since wastes will be compacted, using the C_c for normally consolidated soil above is not appropriate. Use C_r.

C_r is reportedly about 5 to 10% of C_c, source: An Introduction to Geotechnical Engineering, Holtz & Kovacs, Prentiss Hall, 1981, pg 341.

Use $C_r = 0.023$ in calculations

Void Ratio is unknown, but using 0.6 as the void ratio should produce conservative settlement results.

Use $e_o = 0.6$



Use $\gamma = 115$ pcf for wastes & cover

$$\text{settlement} = C_r \frac{H}{1+e_0} \log \frac{\sigma'_{vc} + \Delta\sigma_v}{\sigma'_{vc}}$$ ✓

use $\sigma'_{vo} = 2.25' \times 115 \text{ pcf} = 260$ psf at middle of each layer

Layer ①; $\Delta\sigma_v = (3 \times 4.5') \times 115 \text{ pcf} = 1552$ psf

① settlement $= 0.023 \frac{4.5'}{1+0.6} \log \frac{260+1552}{260} = 0.05' = \underline{\underline{0.6''}}$ ✓

Layer ②; $\Delta\sigma_v = (2 \times 4.5') \times 115 \text{ pcf} = 1035$ psf

② settlement $= 0.023 \frac{4.5}{1+0.6} \log \frac{260+1035}{260} = 0.045' = \underline{\underline{0.5''}}$ ✓

Layer ③; $\Delta\sigma_v = 4.5' \times 115 \text{ pcf} = 520$ psf

③ settlement $= 0.023 \frac{4.5'}{1+0.6} \log \frac{260+520}{260} = 0.03' = \underline{\underline{0.4''}}$

Layer ④ $\Delta\sigma_v = 2' \times 115 \text{ pcf} = 230$ psf

④ settlement $= 0.023 \frac{2.5}{1+0.6} \log \frac{260+230}{260} = 0.01' = \underline{\underline{0.1''}}$

Total Settlement at Cover Surface ≈ $\underline{\underline{1.6''}}$

Conclusion: The total settlement above is overstated since a portion of the settlement should occur during waste placement, reducing the actual settlement of the completed cover system.

The actual cover system settlement is estimated @ 1"

Run-off Velocity/Sheet Flow

Job: Solutia Sauget	Project No. C10000899.00	Page ___ of ___	Sheet 1 of 1
Description: Runoff Velocity Sheet Flow	Computed by M. Brungard	Date 5/10/00	
	Checked by Bill Weber	Date 5/25/2000	

Reference

Purpose: Estimate runoff velocity on cover system under sheet flow conditions.

Method: Use a Time of Travel (T_T) equation to estimate velocity.

Use Flow Length = 300' = (L)
slope = 3% to 12% = (S)
Manning Sheet Flow (n) = 0.15 – for short grass
2 yr - 24 hr Rainfall = 3.28 in from Huff & Angel, 1989 (P)

$$T_T = \frac{0.007 (nL)^{0.8}}{(P)^{0.5} S^{0.4}}$$

Solution: (3%) $T_T = \frac{0.007(0.15(300'))^{0.8}}{\sqrt{3.28} \times 0.03^{0.4}} = .33 \text{ hr} = 1189 \text{ sec}$ ✓

(12%) $T_T = \frac{0.007(0.15(300'))^{0.8}}{\sqrt{3.28} \times 0.12^{0.4}} = .19 \text{ hr} = 683 \text{ sec}$ ✓

(3%) Velocity $= \frac{300'}{1189 \text{ sec}} =$ <u>0.25 ft/sec</u>

(12%) Velocity $= \frac{300'}{683 \text{ sec}} =$ <u>0.44 ft/sec</u>

Suitability of Grassed Surfaces for Erosion Control.

Based on the maximum allowable velocities for grassed channel linings on easily erodible soils, the max. velocity is about 3 ft/sec, from Table 10-5, Municipal Stormwater Management, Debo & Reese, Lewis Publishers, 1995.

* Therefore, grassed surfaces are permissible for the cover.
3 ft/sec >> 0.44 ft/sec

```
Quick TR-55 Ver.5.47   S/N:
Executed: 16:27:44   05-08-2000     s:\1999\00026\SAUGET1.TCT

                    Solutia Sauget Waste Area Peak Flow          (MB)


                         Tc COMPUTATIONS FOR: waste

 SHEET FLOW (Applicable to Tc only)
     Segment ID
     Surface description                          graded waste
     Manning's roughness coeff., n                      0.0110
     Flow length, L (total < or = 300)       ft         300.0
     Two-yr 24-hr rainfall, P2               in          3.280
     Land slope, s                        ft/ft         0.0200
                           0.8
          .007 * (n*L)
     T =  --------------                    hrs          0.05          =   0.05
              0.5    0.4
            P2   *   s

 SHALLOW CONCENTRATED FLOW
     Segment ID
     Surface (paved or unpaved)?
     Flow length, L                          ft           0.0
     Watercourse slope, s                 ft/ft        0.0000

                             0.5
     Avg.V =   Csf *   (s)                 ft/s        0.0000
     where:    Unpaved Csf = 16.1345
               Paved   Csf = 20.3282

     T = L / (3600*V)                        hrs          0.00          =   0.00


 CHANNEL FLOW
     Segment ID
     Cross Sectional Flow Area, a         sq.ft          0.00
     Wetted perimeter, Pw                    ft          0.00
     Hydraulic radius, r = a/Pw              ft         0.000
     Channel slope, s                     ft/ft        0.0000
     Manning's roughness coeff., n                     0.0000

                        2/3     1/2
           1.49   *  r    *  s
     V =  --------------------             ft/s        0.0000
                      n

     Flow length, L                          ft             0

     T = L / (3600*V)                        hrs          0.00          =   0.00

   ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                                                   TOTAL TIME (hrs)       0.05
```

Quick TR-55 Version: 5.47 S/N:

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Solutia Sauget Waste Area Peak Flow

(MB)

CALCULATED
DISK FILE: s:\1999\00026\SAUGET1 .GPD

Drainage Area	(acres)	3	--->	0.0047 sq.mi.
Runoff Curve Number	(CN)	90		
Time of Concentration,Tc	(hrs)	.05		
Rainfall Distribution	(Type)	II		
Pond and Swamp Areas	(%)	0	--->	0.0 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	25		
Rainfall, P, 24-hr (in)	6.02		
Initial Abstraction, Ia (in)	0.222	0.222	0.222
Ia/p Ratio	0.037	0.000	0.000
Unit Discharge, * qu (csm/in)	1191	0	0
Runoff, Q (in)	4.87	0.00	0.00
Pond & Swamp Adjustment Factor	1.00	1.00	1.00
PEAK DISCHARGE, qp (cfs)	27	0	0

Summary of Computations for qu

		Storm #1	Storm #2	Storm #3
Ia/p	#1	0.100	0.000	0.000
C0	#1	2.553	0.000	0.000
C1	#1	-0.615	0.000	0.000
C2	#1	-0.164	0.000	0.000
qu (csm)	#1	1190.884	0.000	0.000
Ia/p	#2	0.100	0.000	0.000
C0	#2	2.553	0.000	0.000
C1	#2	-0.615	0.000	0.000
C2	#2	-0.164	0.000	0.000
qu (csm)	#2	1190.884	0.000	0.000
* qu (csm)		1191	0	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)

Cover System Stormwater Control

URS
7650 West Courtney Campbell Causeway
Tampa, FL 33607-1462
Tel: 813.286.1711

Problem

1- Design a dropstructure to convey stormwater runoff from the top of the landfill to the perimeter ditch located at the North side of the landfill cell.

Given

Landfill drainage Area = 5 Ac.

Ditch lining : Grass

C = 0.8

Solution

- use Concrete structure w/Grate inlet fitted with 24"RCP
- Use Grassed ditch to Convey the flow with the following cross section:

Left side slope = 3:1

Right side slope = 4:1 (adjacent to landfill slope)

Bottom width = 2'

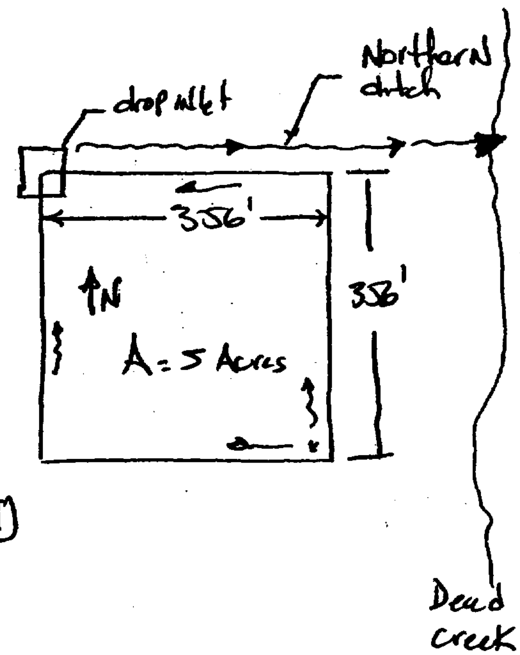
depth = 1.5

7650 West Courtney Campbell Causeway
Tampa, FL 33607-1462
Tel: 813.286.1711

JOB Sauget SHEET 2 OF 3 PROJ. NO.
DESCRIPTION landfill Drainage system COMPUTED BY DCPE DATE 5/1/01
CHECKED BY WJW DATE 5/1/01

Calculations

Use rational method to Calculate Qmax



$Q = CIA$

$C = 0.8$; $A = 5$ Ac

$T_c = \frac{356 \times 2}{60V}$

$V = 1.6$ ft/sec (from Fig 2-1 of TESS manual)

$\therefore T_c \approx 12$ min.

$I_{25,24} = 7.96$ (Fig 4-20a d)

$\therefore Q = 0.8 \times 7.96 \times 5 = 32$ ft^3/sec.

Size Drop inlet Pipe

$V^2 = 2gh$ (assuming Inlet Control)

$\frac{Q^2}{A^2} = 2gh$

$Q^2 = 2ghA^2$

Check head build up for 24-inch pipe

$(32)^2 = 2 \times 32.2 \times h \times (2.76)^2$

$\therefore h \approx 2.0$ ft

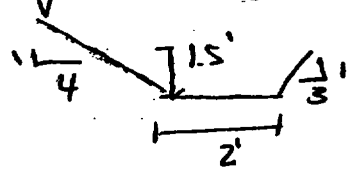
total inside inlet depth = 24" (pipe) + 2' (head) = 4 ft

size ditch @ North end to carry $Q_{max} = 32$ ft³/s.

$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

Assume ditch depth = 1.5 ft & bottom width = 2'

$A = (2 \times 1.5) + 3 (1.5)^2 \times 0.5$
$+ 4 (1.5)^2 \times 0.5$
$= 10.83$ ft²



$P = 12.93$

$R = \frac{10.83}{12.93} = 0.84$

$Q = \frac{1.486}{.02} \times 10.83 \times 0.84^{2/3} \times .005^{1/2} \approx 51$ ft³/sec.

Since $Q_{calculated} > Q_{flow}$. ditch section ok.

Outlet Channel Design

URS

Page 1 of 6

Job: Solutia - Sauget | Project No. C10000 4051.01 | Sheet __ of __
Description: Capacity Check for North Ditch - Downschute | Computed by: WJW | Date: 5/1/2001
Checked by: DG | Date: 5/11/01

Reference

PROBLEM: Will ditch handle required flow?

GIVEN: Ditch dimensions from design drawings

Required flow Q=51 ft³/s (from previous calcs)

REFERENCES: Bedient, Philip B., and Wayne C. Huber, 1992, Hydrology and Floodplain Analysis, 2nd ed., Addison-Wesley Publishing Co., New York.

Chow, Ven Te, Ph.D., 1959, Open Channel Hydraulics, McGraw-Hill Book Company, New York

"Manual for Erosion and Sediment Control in Georgia," 1990, Georgia Soil and Water Conservation Commission.

ASSUMPTIONS: Stated in calcs

CONCLUSION: The calculations show the given channel flowing 20.7 in deep at a velocity of 3.6 ft/s.

The channel is 24 in deep which is sufficient to contain the water

Given a grass lined channel with a bottom slope of 0.4%, the references require the velocity to be less than 5 ft/s. The design velocity is 3.6 ft/s which meets this criteria

∴ The ditch is sufficient as designed.

Form No. 61082-67

URS

Job: Solutia Sauget
Project No. 21000004051.01
Sheet ___ of ___

Description: Capacity Check for North Ditch-Downchute
Computed by: WJW
Date: 5/1/2001
Checked by: DOE
Date: 5/1/01

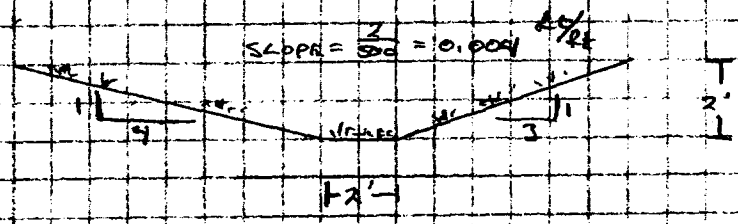
Reference

Solution:

Calc. Depth

Required Flowrate $Q = 51\ ft^3/s$

Channel Dimensions



Manning's $n = 0.025$ (Bedient, 1992)

Using AutoCAD to solve for Mannings Equation

$V = \frac{1.49}{n} R^{2/3} \sqrt{S}$

@ $Q = 51\ ft^3/s$ Depth = 20.8 in

∴ The 24 in deep channel will contain the flow

Consider Velocity

At $Q = 51\ ft^3/s$ the flow velocity is 3.6 ft/s

From Chow Table 7-6 and the Georgia Development Manual Table 6-31, most grasses grown in easily eroded soils with a slope less than 5% should have a water velocity less than 5 ft/s

∴ Given the bottom slope of 0.4% and the water velocity of 3.6 ft/s the designed channel is sufficient.

Form No. 5790P

TABLE 7.1
Values of Roughness Coefficient n in Manning's formula

NATURE OF SURFACE	n MIN	n MAX
Closed Conduits		
Neat cement surface	0.010	0.013
Wood-stave pipe	0.010	0.013
Plank flumes, planed	0.010	0.014
Vitrified sewer pipe	0.010	0.017
Metal flumes, smooth	0.011	0.015
Concrete, precast	0.011	0.013
Cement mortar surfaces	0.011	0.015
Plank flumes, unplaned	0.011	0.015
Common clay drainage tile	0.011	0.017
Concrete, monolithic	0.012	0.016
Brick with cement mortar	0.012	0.017
Cast iron	0.013	0.017
Cement rubble surfaces	0.017	0.030
Riveted steel	0.017	0.020
Canals and ditches, smooth earth	0.017	0.025
Metal flumes, corrugated	0.022	0.030
Canals		
Dredged in earth, smooth	0.025	0.033
In rock cuts, smooth	0.025	0.035
Rough beds and weeds on sides	0.025	0.040
Rock cuts, jagged and irregular	0.035	0.045
Natural Streams		
Smooth and straight	0.025	0.033
Rough weeds and stones	0.045	0.060
Very weedy, deep pools	0.075	0.150
Floodplains		
Pasture	0.025	0.05
Brush	0.035	0.16
Trees		
Dense willows	0.11	0.20
Cleared with stumps	0.03	0.05
Heavy timber	0.08	0.12

Page 4 of 6

RETARDANCE*

of retardance

Ve... ...h
High
Moderate
Low
Very low

High
Moderate
Low
Low
Very low

ble velocity of flow in a t severe erosion in the ible velocities for differ- :tions, recommended on n Service, are shown in

ss for the channel lining the plant will grow and e hydraulic viewpoint, sidered. In general, a ning. On steep slopes, zu, will develop channel- for lining. For slopes te l-forming grasses, no ...ooth brome, are occurs. Because of the asses, the top portion of asses that do not spread ablishment of the lining, ommended. Sometimes il permanent covers by in channels may be con- develop channeled flow,

f grass for channel lining mined from the condition . During the period of

establishment, the grass will grow and the channel will be stabilized under a condition of low degree of retardance. The channel will not reach its maximum capacity until the grass cover is fully developed and well established. Therefore, it is suggested that the hydraulic design of a grassed channel consist of two stages. The first stage (A) is to design the channel for stability, that is, to determine the channel dimensions under the condition of a *lower* degree of retardance. The second stage

TABLE 7-6. PERMISSIBLE VELOCITIES FOR CHANNELS LINED WITH GRASS*

Cover	Slope range, %	Permissible velocity, fps	
		Erosion-resistant soils	Easily eroded soils
Bermuda grass	0–5	8	6
	5–10	7	5
	>10	6	4
Buffalo grass, Kentucky bluegrass, smooth brome, blue grama	0–5	7	5
	5–10	6	4
	>10	5	3
Grass mixture	0–5	5	4
	5–10	4	3
	Do not use on slopes steeper than 10%		
Lespedeza sericea, weeping love grass, ischaemum (yellow bluestem), kudzu, alfalfa, crabgrass	0–5	3.5	2.5
	Do not use on slopes steeper than 5%, except for side slopes in a combination channel		
Annuals—used on mild slopes or as temporary protection until permanent covers are established, common lespedeza, Sudan grass	0–5	3.5	2.5
	Use on slopes steeper than 5% is not recommended		

REMARKS. The values apply to average, uniform stands of each type of cover. Use velocities exceeding 5 fps only where good covers and proper maintenance can be obtained.

* U.S. Soil Conservation Service [41].

(B) is to review the design for maximum capacity, that is, to determine the increase in depth of flow necessary to maintain a maximum capacity under the condition of a *higher* degree of retardance. For instance, if common lespedeza is selected as the grass for lining, the common lespedeza of low vegetal retardance (green, average length 4.5 in.) is used for the first stage in design. Then, in the second stage, the common lespedeza of moderate vegetal retardance (green, uncut, average length 11 in.) should be used. Finally, a proper freeboard is added to the computed

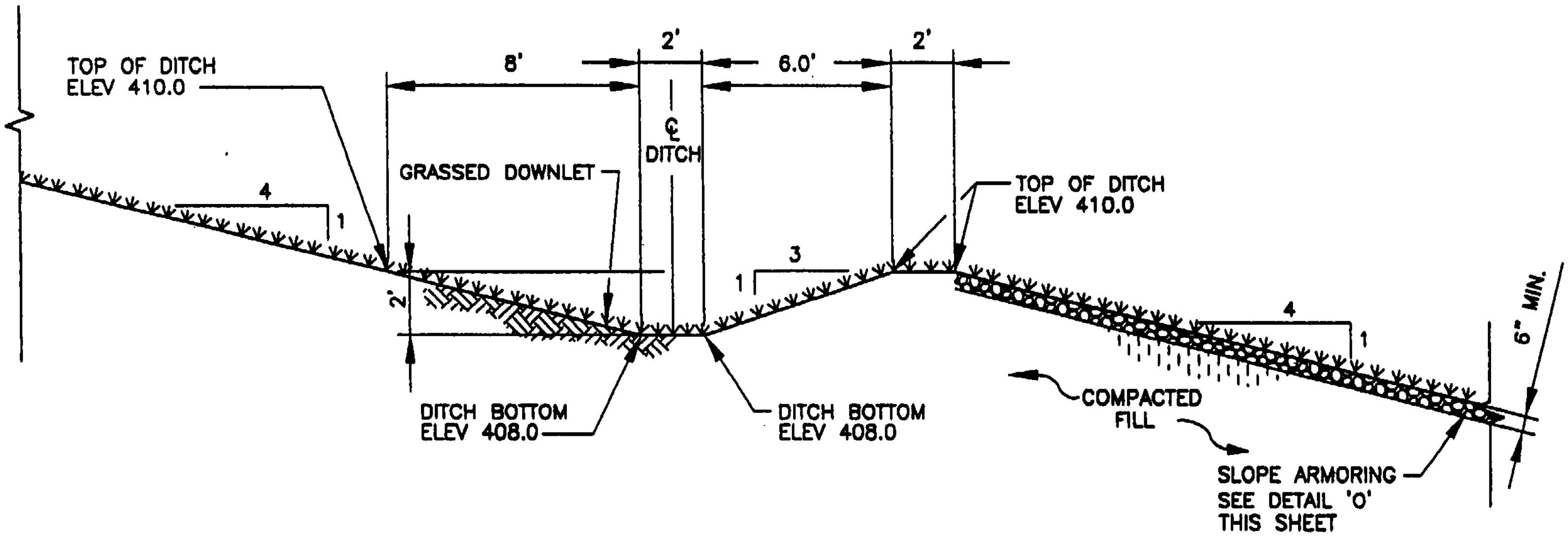
TABLE 6-31

PERMISSIBLE DESIGN VELOCITIES

Cover	PERMISSIBLE VELOCITY[1]		
	Slope range (percent)	Erosion Resistant Soils[5] (ft./sec.)	Easily Eroded Soils[6] (ft./sec.)
Bermuda	0-5 5-10 over 10	6 5 4	5 4 3
Tall Fescue Bahia	0-5 5-10 over 10	5 4 3	5 4 3
Grass-legume mixtures	0-5 5-10[2]	5 4	4 3
Sericea lespedeza Annuals[4] - Small grains (rye, millet) Rye grass	0-5[3]	3.5	2.5
Stone center	All	(as determined by stone size from Rp section)	

1 Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
2 Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
3 Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
4 Annuals - use on mild slopes or as temporary protection until permanent covers are established.
5 Erosion resistant soils include those with a higher clay content and high plasticity. Typical soil textures are silty clay, sandy clay, and clay.
6 Easily erodible soils include those with a high content of fine sand or lower plasticity. Typical soil textures are fine sand, silt, sandy loam, and silty loam.

S:\C10000\40. .1.00\FINAL DESIGN REPORT\FIGURES\FIGURE 5-6.DWG 03/27/01 16:26



NOTE:

SLOPE ARMORING TO BEGIN AT
ELEV 410.0 ALONG DOWNSHUTE.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: W. WEBBER Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC. SAUGET AREA 1**	DRAWING TITLE **DOWNCHUTE SECTION**	FIGURE 5-6

Manning's Equation Output
From ACAD Land Development

Channel Calculator

Given Input Data:

Shape	Trapezoidal	
Solve for	Depth of Flow	
Flowrate	51.0000	cfs
Slope	0.0040	ft/ft
Manning's n	0.0250	
Height	24.0000	in
Bottom Width	24.0000	in
Left Slope	0.2500	ft/ft (V/H)
Right Slope	0.3333	ft/ft (V/H)

Computed Results:

Depth of Flow	20.7989	in
Velocity	3.6477	fps
Full Flowrate	71.5070	cfs
Area	18.0006	ft2
Perimeter	198.8560	in
Flow Area	13.9813	ft2
Flow Perimeter	175.5336	in
Hydraulic Radius	11.4697	in
Top Width	169.5982	in
Flow Condition	Subcritical	

ATTACHMENT 8

REVISED SECTION 5.0 AND FIGURES 5-1, 5-8, 5-9 AND 5-10

5.1 CLOSURE PLANS

The containment cell will incorporate an impermeable cover to reduce infiltration into the completed cell. The cover will be sloped to promote stormwater run-off and will incorporate structural features to direct and control the run-off from the elevated cover. The cover slope also provides for potential settlement of the contained wastes. The impermeable cover will be constructed to completely encapsulate the materials placed within the cell.

5.2 CLOSURE PERFORMANCE STANDARD

The cover system of this landfill is designed to:

- minimize the need for further maintenance, and
- control, minimize or eliminate the post closure escape of materials within the landfill to the ground or surface water surrounding the site.

The closure plan provides an engineered cover system that controls and routes stormwater to reduce cover erosion. The cover will incorporate an impermeable composite lining system that will reduce the infiltration into the wastes and subsequent leachate generation. A geonet drainage composite will intercept and route water infiltrating the cover soil layer to reduce the head on the cover lining system. The cover soil layer will be 24 inches thick to provide adequate rooting depth for the grassing on the cover. The grassing will reduce soil erosion.

A sand layer will be placed over the completed waste fill to provide a gas permeable zone for a gas vent system through the cover system. Vent pipes will penetrate the cover system to provide relief for gases generated by the wastes and to vent barometric pressure changes.

The impermeable cover composite lining system substantially reduces liquid infiltration into the wastes and subsequent leachate generation. The cover system will be installed after all waste materials have been interred there.

5.3 COVER SYSTEM DESCRIPTION

The landfill cover is designed to prevent infiltration of stormwater into the waste material and promote rapid run-off of stormwater during rainfall events. At a minimum, the cover system will include the following from bottom to top:

- 6 inches of tracked in-place sand
- geosynthetic clay liner
- 60-mil HDPE geomembrane (textured)
- geotextile fabric
- geonet drainage layer
- geotextile fabric
- 24 inches of soil and drainage layer to support the vegetation cover

5.4 COVER DESIGN

5.4.1 General

The cover system for the proposed containment cell will be a multi-component composite lining with gas collection and subsurface drainage layers. The proposed cover system is designed to provide a degree of impermeability equivalent to the bottom lining system. Surface grades for the containment cell side slopes are no steeper than 4:1 for ease of mowing and maintenance. The central cover area will have a surface slope between 3 and 12 percent depending on the waste volume. A raised berm around the central cover area routes stormwater to a precast downlet drop box and outlet channel at the toe of the 4:1 side slope. The total landfill plan area is about 5.4 acres. Figure 5-1 shows the proposed configuration of the cover system. Figure 5-2 shows a cross section of the proposed cover system. A description of the cover system components is provided below. The components are described in a bottom to top order.

The subgrade for the cover system will be the waste materials. The waste materials will be graded to mirror the final surface grades on the cover. Clean fill will be used if needed to provide the grades if there is not enough waste fill to meet the required grades. A 6-inch thick sand layer will be pushed and tracked into place over the graded subgrade to serve as the bedding for the linings and serve as a gas collection layer. Four gas vent structures will be distributed around the cover to vent the sand layer to the atmosphere. The vent stack will be constructed of 6-inch diameter PVC piping capped with a hood to prevent precipitation infiltration. The portion of the vent stack below the lining elevation is slotted to provide pneumatic connection to the sand layer. Each vent will include a 20-ft by 20-ft geonet layer to create an enhanced collection zone around the vent. Each vent stack excavation will be backfilled with gravel to provide a stable foundation. Each vent pipe passes through a fabricated boot in the HDPE lining to prevent seepage from entering the cell. Figure 5-3 presents a detail of the vent structure.

The 6-inch sand layer will be the bedding layer for the GCL materials. Bedding layer soils will have clods no larger than two inches, will be placed and compacted to 90% Standard Proctor Density and will have a moisture content at or near optimum. Bedding layers will be smooth with no ruts or sharp edges before, during and after installation of the overlying geosynthetic material. They will provide a surface capable of supporting the geosynthetics and other layers in the liner system. Specification 02200 - Earthwork, included in Appendix E, Technical Specifications, of the Design Report, will be used for control of placement of the geosynthetic bedding layers in the liner system.

A GCL will be placed over the sand layer. The GCL will be rolled into place and overlapped with adjacent panels. The GCL used in the cover will be a commercially available material composed of two geotextile layers sandwiching bentonite clay granules. The hydraulic conductivity of the GCL will be no greater than 1x 10^{-8} cm/sec. The GCL will have an internal shear strength of 50 psf (nominal) and a tensile grab strength of at least 50 pounds. Lateral and longitudinal seams will be completed by overlapping adjacent panels.

A 60-mil High Density Polyethylene (HDPE) lining will be placed directly over the GCL. The GCL and HDPE composite lining system extends over the entire lined waste cell and is buried in an anchor trench just outside the limits of the bottom lining anchor trench. The HDPE lining panels will be heat seamed to form a continuous membrane barrier. The seaming will be either pressure or vacuum tested to verify the integrity of the seams. Mechanical tests of the seam integrity will be performed by removing test samples from the completed lining and destructively testing the samples. The sample locations from the lining will be patched with an extrusion welded HDPE patch. The primary lining in the cover system will be constructed with 60-mil

HDPE membrane. The HDPE lining will be textured and will contain ultraviolet protectants. Although the HDPE manufacturer for this installation is currently undefined, manufacturers such as GSE Lining Technology or Poly-Flex Inc. produce linings meeting the requirements of the State of Illinois.

A geotextile/ geonet/ geotextile drainage composite will be placed directly on the HDPE lining to serve as a subsurface drain. The drainage composite will extend over the entire cover area and connect to perforated piping at the edge of the cover area. The perforated piping is connected to gravel covered outlets at ground surface to drain the collected water. The gravel prevents access to the drainage piping by animals.

A 24-inch earthen cover soil layer will be constructed over the geosynthetic drainage composite layer to provide a vegetated cover. The cover soil material will be a native soil suitable for grass growth and with a maximum particle size of ¼-inch. The cover soil layer will be compacted to at least 90 percent of the fill's maximum dry density as determined by ASTM D-698 to provide stability to the cover soil for mowing and maintenance. The grassing will be with grass seed mixes appropriate for Illinois, specifically IDOT Section 250 Seed Mixture Class 1.

HDPE membrane will be manufactured by GSE, Serrott or equivalent. Geotextile will be manufactured by Mirafi or equivalent. Geonet and geonet will be manufactured by Tenax or equivalent. GCL will be manufactured by CETCO, GSE, Serrot or equivalent. Manufacturers technical data sheets for these geosynthetics are included in Appendix H. Manufacturers technical data sheets for all geosynthetic components including Geomembrane, GCL, geotextile, geonet and geogrid are included as Appendix H of the Design Report.

5.4.2 Minimization of Liquid Migration

The proposed cover design provides a substantial long-term minimization of liquid migration through the cover system. Modeling of the cover system was performed using HELP. The model results indicate that the infiltration through the cover system is less than 1/1000 of 1 percent of the total precipitation falling on the cover system. The HELP results are provided in Appendix C.

5.4.3 Maintenance Needs

The proposed cover system was designed to minimize the amount of maintenance and to allow easy maintenance. The cover system incorporates relatively gentle slopes for ease of mowing. The lower portions of the side slopes include rip rap armoring to reduce erosion of the side slopes during flooding events in Dead Creek. The berm around the central cover area reduces the amount of stormwater flowing down the side slopes, reducing the erosion potential. The central cover area slopes are mild to reduce stormwater run-off velocity and erosion. The gravel covered subsurface drains on the cover help keep animals out of the drainage collection system to avoid gnawing injury to the system.

5.4.4 Drainage and Erosion

The cover system design incorporates a berm around the central cover area to route stormwater off the cover through an armored downchute. The velocity of sheet flow run-off on the cover varies between 0.25 and 0.44 ft per second for slopes between 3 and 12 percent, respectively. Grassed surfaces are appropriate for these flow velocities. Calculations for the sheet flow velocities are provided in Appendix D.

The geosynthetic drainage composite used as the subgrade drain has a transmissivity of 9×10^{-1} cm^2/sec. The geonet will be a 3-dimensional HDPE net between two layers of non-woven geotextile fabric. The drainage composite will directly contact the underlying HDPE lining. Calculations in Appendix C show that the geotextile will resist clogging by the native sandy silt soils expected for use as the cover soil layer.

Free drainage of the subgrade drain is confirmed in the HELP model calculations. The liquid head in the subgrade drain does not exceed 4.2 inches under peak daily conditions. The average annual head in the subgrade drain is 0.007 inches. The HELP model results are provided in Appendix C.

Free drainage of the cover surface is maintained by adequate drainage course slopes. The central cover area will have a minimum slope of 3 percent. A raised earthen berm around the entire central cover area will form a 1-ft deep swale to route the stormwater flow to the single stormwater drop structure. The swale slope will be 1 percent. A combination of precast concrete drop boxes and HDPE piping will carry the stormwater down the exterior slope of the cell. A grassed lined outlet channel will be constructed at the foot of the 4:1 (H:V) slope to dissipate the hydraulic energy and route the stormwater to Dead Creek. These appurtenant structures are designed to handle a 32 cfs peak flow. The stormwater calculations for the cover system are provided in Appendix D.

5.4.5 Settlement and Subsidence

The foundation soils beneath the proposed containment cell are primarily sandy soils with little potential for consolidation or creep settlement. Most settlement will be immediate. The settlement potential for the cell is described in a previous paragraph. Settlement potential for the soil lining is minimal due to the components receiving moderate compactive effort and the total overburden weight being minor.

The wastes placed in the cell are largely inorganic soils with limited digestible material. The wastes will be dried prior to placement in the cell and they will be compacted during placement. The degree of compaction will not be specified for waste placement. Consolidation of the waste mass is not likely to be significant. Consolidation testing on the proposed wastes has not been performed. Correlations for consolidation potential generally show that settlement potential decreases as the material's liquid limit and moisture content decrease. In addition, the mechanically compacted soil should behave as an over-consolidated soil that has significantly less settlement potential than a normally-consolidated soil. The 16-ft maximum waste thickness makes it unlikely that the overburden stress will approach the normally-consolidated range for the wastes, therefore the over-consolidated settlement behavior should be valid for this analysis. The duration of waste placement will allow some of the potential settlement to occur prior to cover placement, further limiting the cover settlement. The cover system settlement is estimated as about 1-inch at the center of the cover. That deflection produces no measurable reduction in the cover grade. The waste consolidation calculations are provided in Appendix D.

The potential settlement for the foundation and wastes will not measurably alter the surface grades of the cover system. The precipitation runoff should not be affected by any cover settlement and the infiltration predicted by the HELP modeling should be valid for the life of the cell.

5.4.6 Freeze/Thaw Effects

The frost penetration depth in this region is about 3 ft. The GCL in the cover system will be 2 ft below ground surface. The cover system GCL will be subject to freeze/thaw action.

Freeze/Thaw action can reduce the effectiveness of impermeable soil barriers. This cover system will use a GCL as the impermeable soil barrier. Testing performed by GeoServices Inc. for James Clem Corporation in 1988, showed that the GCL becomes about one-half order of magnitude more permeable when subjected to freeze/thaw cycling. The permeability of the GCL used in the HELP modeling does include this reduction for the freeze/thaw effects. The infiltration rate through the cover system should represent long-term performance.

5.4.7 Anchorage

The anchor trench around the perimeter of the landfill will be excavated and the liner segments placed such that the field welds will run up and down the side slopes of the berms. The liner will be placed into the anchor trench, the backfill soils will be placed and then compacted. A detail of the anchorage for the geosynthetic liner is shown on Figures 5-4 and 5-5.

5.5 RUN-OFF CONTROL SYSTEMS

Stormwater run-off control during containment cell construction and filling will be performed as follows.

5.5.1 Design and Performance

During construction, storm water in the cell will be pumped from the cell and discharged to Dead Creek. During sediment transfer, storm water in the cell will be treated, as required, and discharged. For most of the waste placement process, stormwater is completely contained within the lined cell. All stormwater contacting the placed sediments will be handled by pumping to the filter dam at the downstream end of Creek Segment B.

During waste placement, the waste fill will be graded to create a collection sump from which stormwater will be pumped. Since the waste placement period is relatively short (about 6 months), the design storm for the open cell is a 1-year, 24-hour event. The rainfall amount is 2.71 inches. The stormwater volume from that storm is about 222,000 gallons. Approximately ¼ of the cell area would need to be left with a 1-ft depth to accommodate that stormwater volume.

For a 25-year, 24-hour storm, the rainfall amount is 6.02 inches. The stormwater volume from that storm is about 495,000 gallons. Approximately ¼ of the cell area would need to be left with a 2-ft depth to accommodate that stormwater volume.

Figure 5-4 presents the detail for run-off control during placement within the landfill. To reduce the stormwater volume, impermeable covers may be placed over the wastes to prevent contact with the stormwater. Stormwater ponded on the impermeable covers will be discharged to Dead Creek. As the waste elevation approaches the perimeter berm elevations, impermeable covers will be required over the wastes to limit stormwater contact.

Once the cover is installed, sedimentation will be controlled using best management practices. After vegetation is established there is no need to control runoff from the cell. Storm water runoff will be routed to a grassed lined outlet channel north of the cell that discharges to Dead Creek. Drawings for this swale, which is designed to handle a 25 year, 24 hour storm, are included as Figures 5-1 and 5-6 in the Design Report.

Perimeter ditching and a controlled downlet structure for stormwater falling on the landfill are incorporated into the design. At the confluence of the two swales located at the northwest corner of the landfill (at the top of the berm) stormwater will flow into two interconnected drop inlets placed at different elevations. The first pre-cast inlet will be placed at the confluence of the two swales and the second inlet will be placed immediately to the north and set at a lower elevation. The stormwater will then flow out of the lower inlet into the grassed lined channel with an ultimate outfall to Dead Creek, located east of the landfill. In addition, rip-rap will be added to the grassed lined channel, as appropriate, to provide further erosion protection.

5.5.1.1 Calculation of Peak Flow

Two methods were used to estimate the peak flow from the cover system; the Rational Method and TR-55. The calculations and the design of the inlet drainage structures are based on a 25-year, 24-hour storm event. Rainfall frequency distributions were taken from *Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois*, by Huff and

Angel. The original calculations for the stormwater system were performed using the TR-55 model. To estimate the time of concentration for sheet flow using TR-55, the model uses the following Manning's kinematic equation to compute T_c,

$$T_c = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,S^{0.4}}$$

Where:

T_c = Travel time (hr)
n = Manning's roughness coefficient
L = Flow length (ft)
P_2 = 2-year, 24-hour rainfall (in),
S = Slope of hydraulic gradient line (land slope, ft/ft)

The 2-year, 24 hour storm event is recommended for sheet flow distances that are less than 300 feet by TR-55. The peak flow for the 25-year, 24-hour storm is 27 cfs. The rational method was also used to determine the total runoff from the cover system and to size the inlet system. Based on the Rational method, a peak flow from the cover system is calculated to be 32 cfs. The cover system appurtenant structures were designed to handle the 32 cfs peak flow. These calculations are included in Appendix D.

At the confluence of the two swales located at the northwest corner of the landfill (at the top of the berm) stormwater will flow into two interconnected drop inlets placed at different elevations. The first pre-cast inlet will be placed at the confluence of the two swales and the second inlet will be placed immediately to the north and set at a lower elevation. Collected stormwater will flow out of the lower inlet into the grassed lined drainage ditch with an ultimate outfall to Dead Creek, located east of the landfill. In addition, rip-rap will be added to the grassed lined channel, as appropriate, to provide further erosion protection.

5.5.1.2 Management of Collection and Holding Units

The waste cell will be actively managed by the construction contractor to minimize delays to the work progress. The cell will be pumped out as soon as possible to resume the waste placement. Tank trucks, mobile tanks, or lined pools may be used to store stormwater and leachate that has contacted the wastes. The liquids will be treated onsite and discharged or will be transported to a POTW for treatment and disposal.

5.5.1.3 Construction

The stormwater run-off control system will be constructed primarily of waste materials and will be contained within the lined containment cell. The run-off control system will incorporate requirements to maintain storage capacity in a portion of the waste fill area or provide impervious barriers to avoid waste contact. The requirements for run-off control are contained in Appendix D. A construction quality control program will only assure the retention volume is met since the configuration changes daily and the cell is lined. When impervious linings are used, the retention volume may be reduced in proportion to the area covered.

5.5.1.4 Maintenance

The run-off control system will require daily maintenance to accommodate the daily filling progress. Maintenance activities will be limited to providing the required retention volume within the waste area.

5.6 CONTROL OF WIND DISPERSAL

The waste materials will consist primarily of soil and organic materials. The materials may produce dust if allowed to become too dry. Dust will not be allowed from the operations and the waste fill will be sprinkled with water to reduce any dust generation.

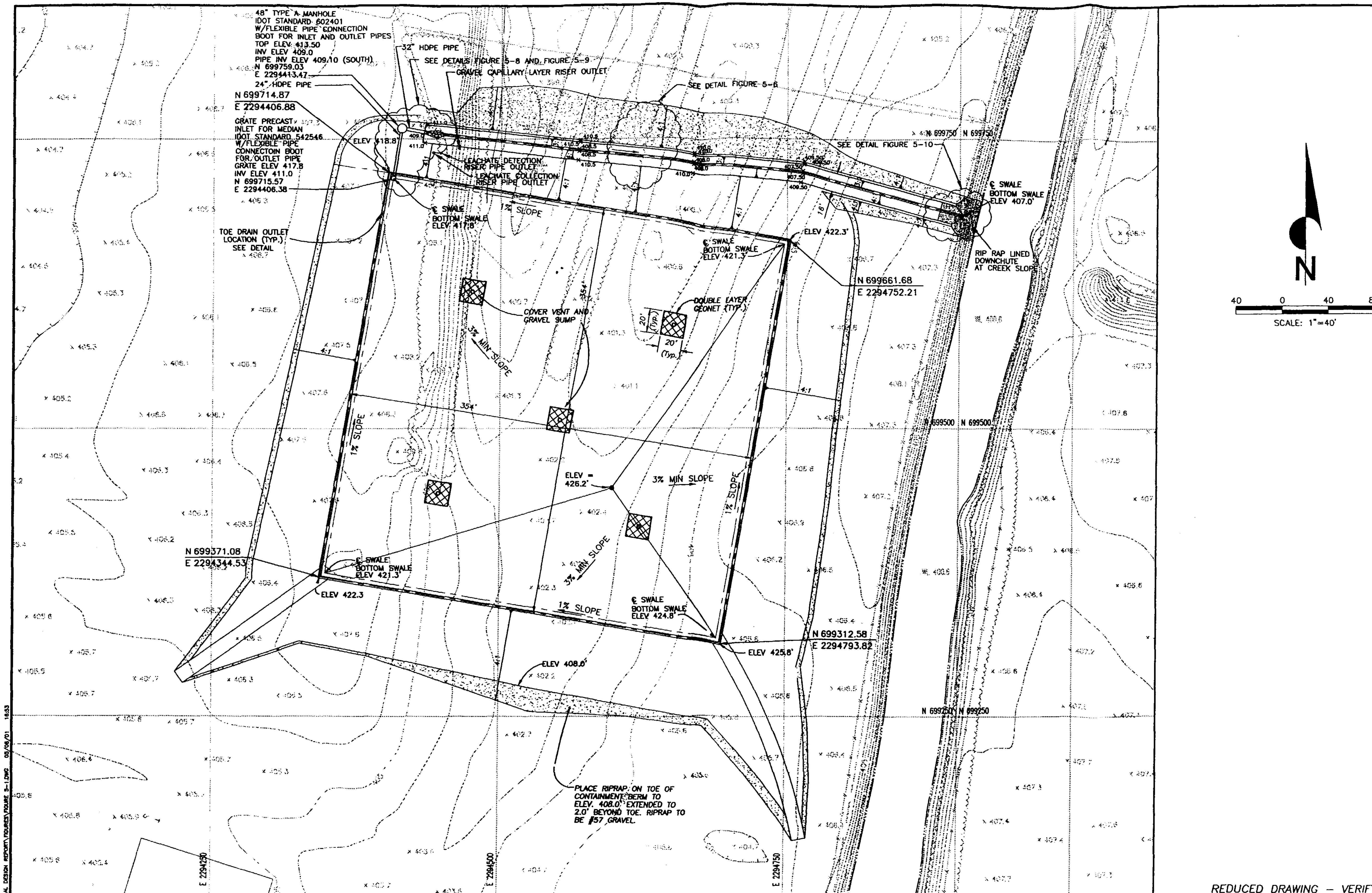
5.7 POST-CLOSURE RUN-OFF

Surface water run-off will be controlled by landscaping and diversion structures to promote run off away from the landfill. Erosion control will be maintained by appropriate landfill contouring and establishment of grass vegetation to stabilize the soil cover.

Surface run-off occurring after closure will not contact the waste material and therefore will be considered non-contaminated. Following closure of the landfill, stormwater will be discharged directly off-site to Dead Creek.

5.8 DRAINAGE STRUCTURES

Drainage structures used in the engineering design for stormwater management may include half-round corrugated metal pipe (CMP) channels, earth berms and channels, and rip rap channels. Drainage structures will be specified that adequately manage the volume of stormwater. Figure 5-1 presents a plan view of the final cover and stormwater management system for the cell. Earth berms and channels may be used to control on-site surface waters. Figure 5-5 presents the final cover system runoff control berm and swale. A cross section of the grassed lined stormwater channel located north of the landfill is shown in Figure 5-6. Figure 5-8 presents a profile of the landfill drop structure which routes collected stormwater to the grassed lined channel. Figure 5-9 presents the outlet detail for the drop structure to the grassed lined channel (Figure 5-6). Figure 5-10 presents the profile of the outlet channel at Dead Creek.



REDUCED DRAWING – VERIFY SCALE

REV	DESCRIPTION OF REVISION	BY	DATE

DESIGNED BY: M. BRUNGARD
DRAWN BY: C. BRADFORD
CHECKED BY: G. WANTLAND
PROJECT MANAGER: G. WANTLAND
DATE: APRIL 2, 2001

URS

URS Corporation Southern
7650 West Courtney
Campbell Causeway
Tampa, FL 33607-1462
No. 00000002

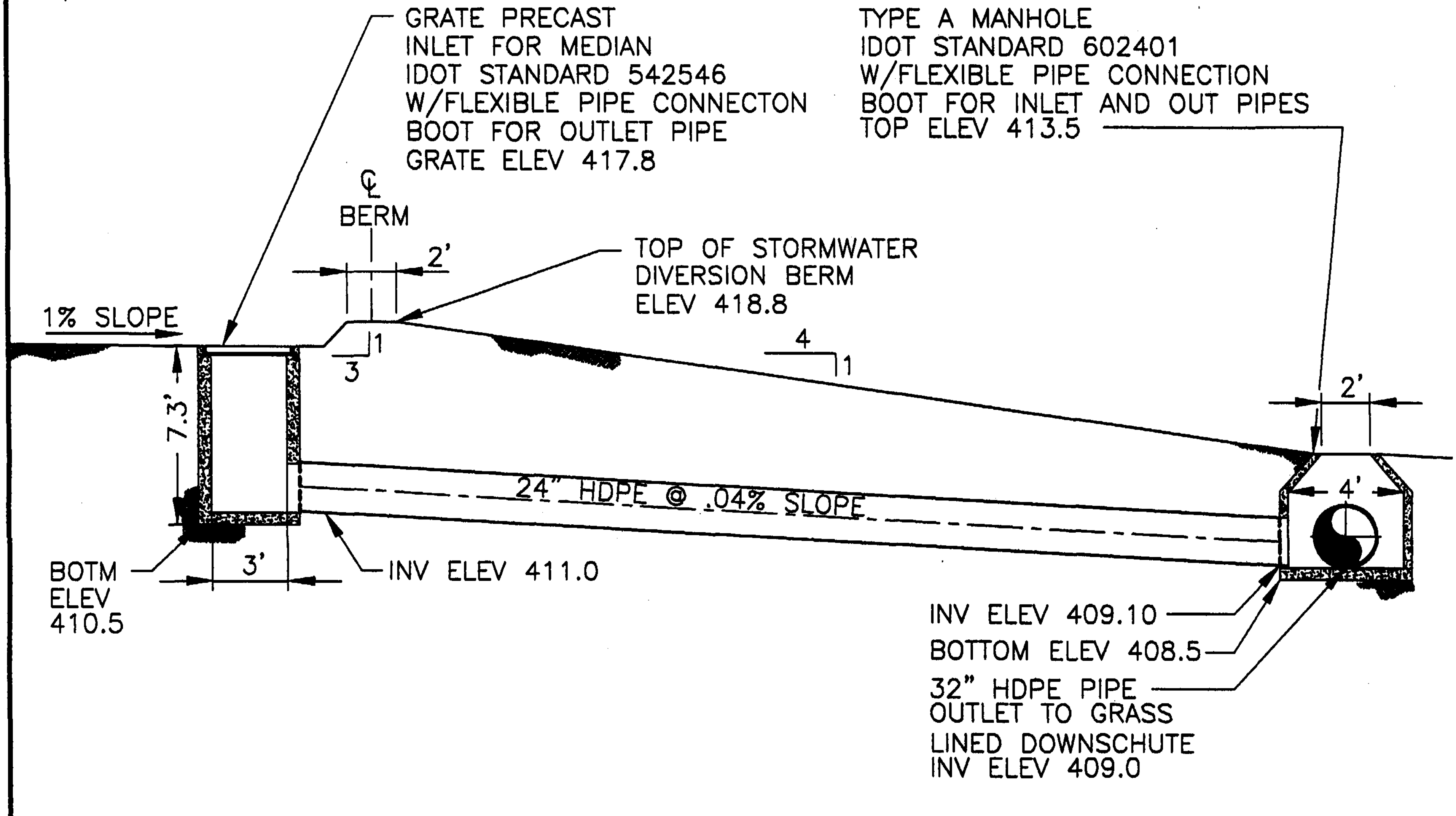
SOLUTIA INC.
SAUGET AREA 1
CAHOKIA, ILLINOIS

COVER SYSTEM PLAN

PROJECT NUMBER
C100004051.00

FIGURE
5-1

S:\C10000\4000\4051.00\FINAL DESIGN REPORT\FIGURES\FIGURE 5-1.DWG 05/08/01 16:53

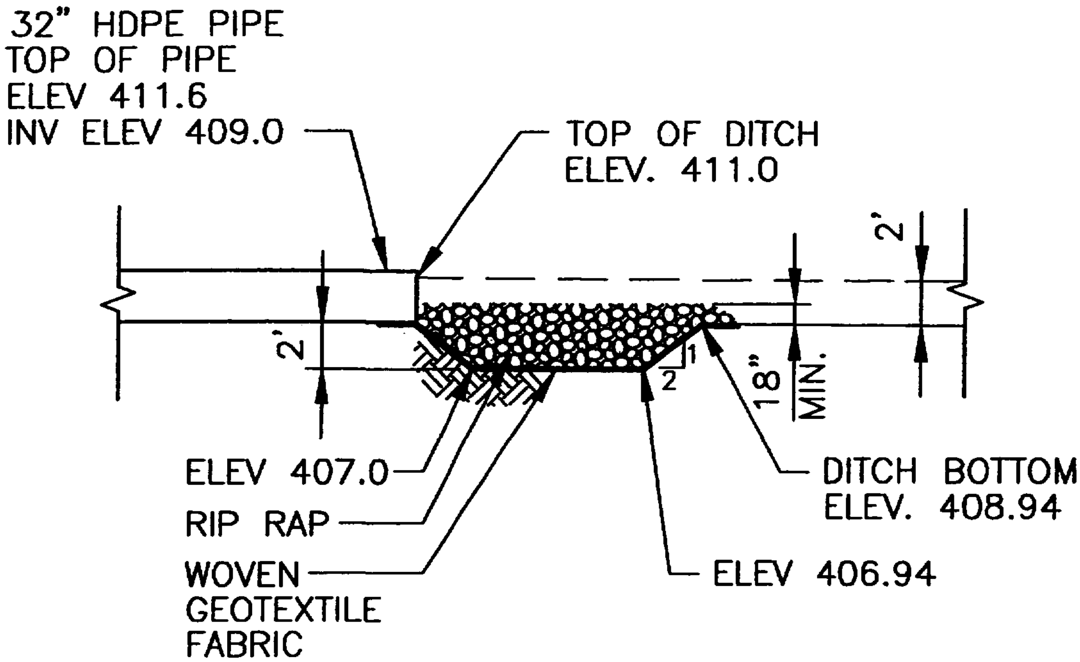


NOTE:

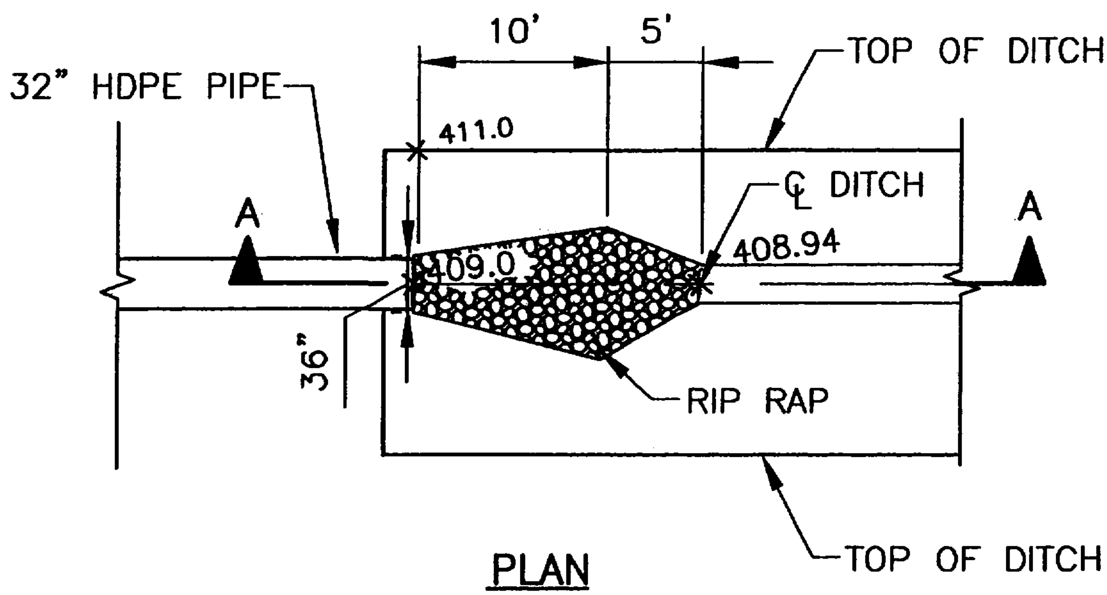
1. NOT FOR CONSTRUCTION.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00 URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Drawn: BAD Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	PROJECT NAME **SOLUTIA INC. SAUGET AREA 1**	DRAWING TITLE **LANDFILL DROP STRUCTURE**	FIGURE 5-8



SECTION A–A



PLAN

NOTE:
1. NOT FOR CONSTRUCTION.

SCALE = N.T.S.

PREPARED FOR: SOLUTIA URS JOB NUMBER: C100004051.00	Drawn: W. WEBER	PROJECT NAME SOLUTIA INC. SAUGET AREA 1	FIGURE
URS Corporation Southern 7650 West Courtney Campbell Causeway Tampa, FL 33607-1462 No. 00000002	Design: GARY WANTLAND Checked: GARY WANTLAND Date: APRIL 2, 2001	DRAWING TITLE DOWNCHUTE OUTLET DETAIL	5-9

ATTACHMENT 9

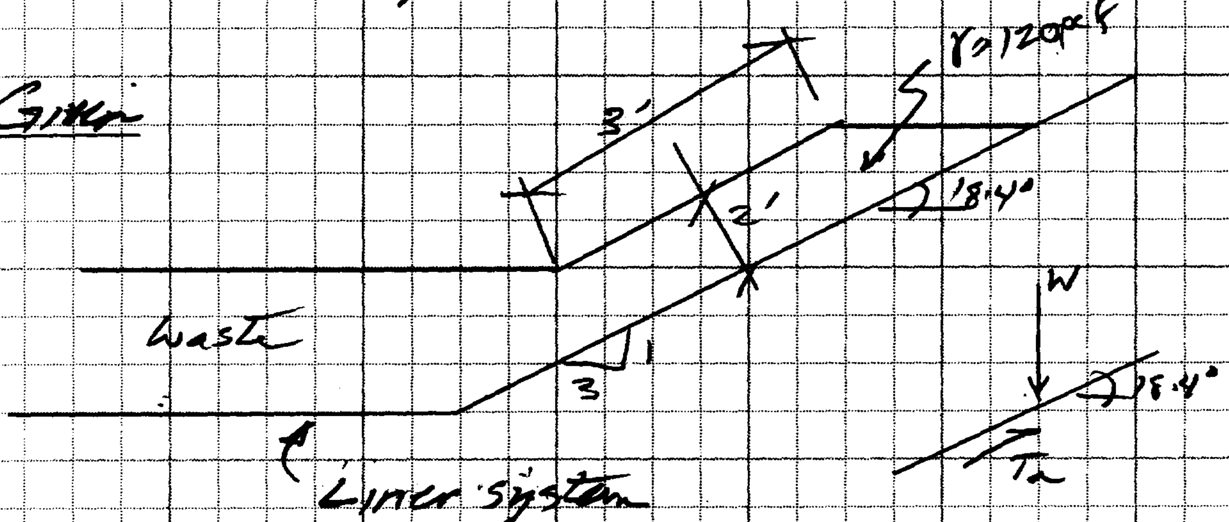
GEOSYNTHETIC CLAY LINER CALCULATIONS

URS

Job: Solutia Sauget | Project No. C1-4122.00 | Sheet ___ of ___
Description: GCL Internal Shear Strength Calculation | Computed by: Gmw | Date: 4 July 01
Checked by: TPA | Date: 5 July 01
Reference

Problem: Evaluate the required internal friction angle for the GCL material on the slope

Given:



Assume critical interface is within GCL

Using the industry published shear strength value of 500 psf for Bentofix NSL

$$T_a = C_a + W \cos\beta \tan\phi_i$$

$$500 = C_a + W \cos(18.4) \tan\phi_i$$

Published adhesion values for GCL materials ranges from 200 - 300 psf use 250 psf for interface adhesion for GCL/soil interface

URS

Job: Solutia Sauget
Description: GCL
Project No.:
Computed by: G[illegible]
Sheet ___ of ___
Date
Checked by
Date

Reference

$W = 2 ft \times 3 ft \times 120 pcf = 720 psf$

$\therefore \tan \phi_i = \frac{500 - 250}{720 \cos(18.4)} = 0.366$

and $\phi_i \cong 20°$

For $FS = 1.5$ $\phi_i = 30°$

Note: This internal friction value is within the low end of the range of values reported by the industry. Also this is not the most critical interface within the system.

ATTACHMENT 10

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR GEOSYNTHETIC (TABLE 1: GEOSYNTHETIC MATERIAL PROPERTIES

TABLE 1

GEOSYNTHETIC MATERIAL PROPERTIES
SAUGET AREA 1 TSCA LANDFILL
SOLUTIA INC.
CAHOKIA, ILLINOIS

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
HDPE Geomembrane					
Smooth	Liner Thickness, mils (nominal)	ASTM D5199	60	mils	Per Roll
	Density (g/cc)	ASTM D1505-A	0.94	g/cc	200,00 lbs
	Tensile Properties (min. aveg.)	ASTM D 638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)			20,000 lbs
	1. Tensile Strength @ Yield (ppi)		126	lbs/in.	
	2. Tensile Strength @ Break (ppi)		228	lbs/in.	
	3. Elongation @ Yield (%)		12	%	
	4. Elongation @ Break (%)		700	%	
	Tear Resistance (min. ave.)	ASTM D 1004 Die C	42	---	45,000 lbs
	Dimensional Stability % Change Each Direction	ASTM D 1204 212 °F 1 hr	± 2		
	Stress Crack Resistance (hrs)	ASTM D 5397	200	hrs	Per Batch
	Puncture Resistance (min. aveg.)	ASTM 4833	108	lbs	45,000 lbs
	Carbon Black Content (%)	ASTM D 1603	2	%	20,000 lbs
	Carbon Black Dispersion	ASTM D 5596	A1, A2 and B1		45,000 lbs
	Oxidative Induction Time (OIT)				200,000 lbs
	(a) Standard OIT (min. aveg.) -or-	ASTM D 3895	100	min.	
	(b) High Pressure OIT (min. aveg.)	ASTM D 5885	400	min.	

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
	UV Resistance (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.) - % retained after 1600 hrs	GM 11 ASTM D 3895 ASTM D 5885	 Not Recommend 50	 N/A %	Per Batch
HDPE Geomembrane					
Textured	Liner Thickness, mils (nominal)	ASTM D 5199	60	mils	Per Roll
	Density (g/cc)	ASTM D 1505-A	0.94	g/cc	200,000 lbs
	Asperity Height	GM 12	10	mils	Per Roll
	Tensile Properties (min. aveg.) 1. Tensile Strength @ Yield (ppi) 2. Tensile Strength @ Break (ppi) 3. Elongation @ Yield (%) 4. Elongation @ Break (%)	ASTM D 638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)	 126 90 12 100	 lbs/in. lbs/in. % %	 --- --- --- ---
	Tear Resistance (min. aveg.)	ASTM D1004 Die C	42 lbs	lbs	
	Dimensional Stability % Change Each Direction	ASTM D 1204 212 °F 1 hr	± 2	---	
	Stress Crack Resistance (hrs)	ASTM D 5397	200	hrs	
	Puncture Resistance (min. aveg.)	ASTM 4833	90	lbs	
	Carbon Black Content (%) Carbon Black Dispersion	ASTM D 1603 ASTM D 5596	2 A1, A2 and B1	hrs %	
	Oxidative Induction Time (OIT) (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.)	 ASTM D 3895 ASTM D 5885	 100 400	 min. min.	

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
	UV Resistance	GM 11			Per Batch
	(a) Standard OIT (min. ave.)	ASTM D 3895	Not Recommend	N/A	
	-or-				
	(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs	ASTM D 5885	50	%	
Geotextile					
	Mass per Area	ASTM D 5261	16	oz/yd^2	
	Grab Strength	ASTM D 4632	380	lbs	
	Elongation	ASTM D 4632	60	%	
	AOS	ASTM D 4751	100	U.S. Sieve	
	Permittivity	ASTM D 4491	0.7	sec^{-1}	
	Trapezoidal Tear Strength	ASTM D 4533	145	lbs	
	Burst Strength	ASTM D 3786	750	psi	
	Puncture Strength	ASTM D 4833	240	lbs	
Geonet					
	Density	ASTM D 792 or D 1505	0.90 min.	g/cu cm	1 per batch
	Thickness	ASTM D 5199	200 min.	mils	4 per roll
	Melt Flow Index	ASTM D 1238	1.0 max.	g/10 min.	1 per batch
	Carbon Black Content	ASTM D 1603	2-3 range	%	1 per batch
	Tensile Strength at Break:				
	• Machine Direction	ASTM D 4595	360 (min.)	lbs/ ft	1 / 40,000 ft^2
	• Cross Direction	ASTM D 4595	200 (min.)	lbs/ ft	1 / 40,000 ft^2
	Transmissivity	ASTM D 4716	1.0	cm^2/sec	1 per shift

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
Geosynthetic Clay Liner Unreinforced	Bentonite Swell Index	ASTM D 5890	24	mL/2g min.	1 per 50 tonnes
	Bentonite Fluid Loss	ASTM D 5890	18	mL max.	1 per 50 tonnes
	Bentonite Mass/Area	ASTM D 5993	0.75	lb/ft^2	40,000 ft^2
	GCL Grab Strength	ASTM D 4632	75	lbs	200,000 ft^2
	GCL Peel Strength	ASTM D 4632	N/A	N/A	N/A
	GCL Index Flux	ASTM D 5887	$1x10^{-8}$	$m^3/m^2/sec$	Weekly
	GCL Permeability	ASTM D5084	$5x10^{-9}$	cm/s	Weekly
	GCL Hydrated Internal Shear Strength	ASTM D 5321	50	psf	Periodic
	Internal Friction Angle	ASTM D 6243	30	degrees	Periodic
Reinforced	Bentonite Swell Index	ASTM D 5890	24	mL/2g min.	1 per 50 tonnes
	Bentonite Fluid Loss	ASTM D 5890	18	mL max.	1 per 50 tonnes
	Bentonite Mass/Area	ASTM D 5993	0.75	lb/ft^2	40,000 ft^2
	GCL Grab Strength	ASTM D 4632	90	lbs	200,000 ft^2
	GCL Peel Strength	ASTM D 4632	15	lbs	40,000 ft^2
	GCL Index Flux	ASTM D 5887	$1x10^{-8}$	$m^3/m^2/sec$	Weekly
	GCL Permeability	ASTM D5084	$5x10^{-9}$	cm/s	Weekly
	GCL Hydrated Internal Shear Strength	ASTM D 5321	500	psf	Periodic

Material Type	Property	Test Method	Requirements		Frequency
			Value	Units	
	Internal Friction Angle	ASTM D 6243	30	degrees	Periodic

ATTACHMENT 11

TECHNICAL SPECIFICATION 02246 (GEONET)

SECTION 02246

GEONET

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes the requirements for geonet procurement, transportation, storage, handling and installation.

1.2 REFERENCES

A. ASTM D413 - Standard Test Methods for Rubber Property – Adhesion to Flexible Substrate.

B. ASTM D792 - Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.

C. ASTM D1238 - Condition E Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

D. ASTM D1505 - Test Method for Density of Plastics by the Density – Gradient Technique.

E. ASTM D1603 - Test Method for Carbon Black in Olefin Plastics.

F. ASTM D4439 - Terminology for Geosynthetics.

G. ASTM D4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In-plane Flow) of Geotextiles and Geotextile Related Products.

H. ASTM D4595 - Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method.

I. ASTM D5199 - Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

1.3 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement, transport, stockpiling or use.

3. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

4. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

5. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted within 1 day of receipt.

6. Contractor shall submit signed documentation that the geonet was installed in accordance with the Plans and Specifications.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the product.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of superintendent to be assigned to the project including dates/duration of employment. The superintendent shall have demonstrated experience of two similar projects.

2. A list of personnel to be performing field seaming operations with pertinent experience information.

3. All geosynthetic quality control certificates.

1.4 TESTING

A. Contractor shall retain the services of an independent testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

1.5 QUALITY ASSURANCE

A. Geonet shall be free of defects, rips, holes, or flaws.

B. It shall be manufactured in widths and lengths that will permit installation of geonet with as few laps as possible.

C. Geonet shall be marked with the Manufacturer's name, product identification, lot number, roll number, and roll dimensions.

D. Contractor shall provide a storage area such that geonet is protected from mud, dirt, dust, debris, and exposure to ultraviolet (UV) light and heat.

E. Contractor shall submit all material and workmanship warranties for the geonet installation.

1.6 GEONET TRANSPORTATION, HANDLING, AND STORAGE

A. Transportation of geonet is responsibility of Contractor, who shall be liable for all damages to geonet prior to and during transportation to Site.

B. Handling, storage, and care of geonet on-site is responsibility of Contractor prior to, during and after geonet installation.

C. Contractor shall retain ownership of geonet until installation is accepted by the Construction Manager. Contractor shall be liable for all damages to geonet incurred prior to final acceptance of installation by Construction Manager.

PART 2 PRODUCTS

2.1 GEONET

A. Provide products for the geonet comprised of high-density polyethylene (HDPE). The geonet shall be manufactured by extruding two sets of strands to form a three dimensional structure to provide plane flow and shall meet the following minimum average roll values except as noted.

GEONET PROPERTIES			
Property	**Test**	**Value**	**Units**
Density	ASTM D792 or D1505	0.90 min.	g/cu cm
Thickness	ASTM D5199	200 min.	mils
Melt Flow Index	ASTM D1238	1.0 max.	g/10 min.
Carbon Black Content	ASTM D1603	2-3 range	%
Tensile Strength at Break: • Machine Direction • Cross Direction	 ASTM D4595 ASTM D4595	 360 (min.) 200 (min.)	 lbs/ft lbs/ft
Transmissivity	ASTM D4716	1.0	cm^2/sec

PART 3 EXECUTION

3.1 GEONET PLACEMENT AND HANDLING

A. Handle all geonet in such a manner as to ensure it is not damaged in any way. Damaged geonet shall not be installed. If geonet is damaged during or after installation, it shall be replaced.

B. Geonet shall be anchored and installed by rolling it down the slope so as to continually keep the material in tension.

C. In the presence of wind, geonets shall be weighted with sandbags or equivalent. Such sandbags shall be installed during placement and shall remain until replaced with earthen cover material.

D. Geonets shall be cut using an approved cutter only. If in place, special care must be taken to protect geomembrane from damage which could be caused by cutting of geonets.

E. During placement, care shall be taken not to entrap in geonet stones, excessive dust, or moisture that could hamper subsequent seaming. If geonet is not free of debris and soil prior to installation, Contractor shall clean geonet prior to installation.

F. The Contractor shall examine the geonet over the entire surface, after installation, to ensure that no potentially harmful foreign objects are present. Any foreign objects so encountered shall be removed by Contractor, or geonet shall be replaced.

G. Geonet shall not be welded or tack welded to the underlying geomembrane.

3.2 QUALITY CONTROL

A. Visual inspections of shipment and storage activities shall be made by the Construction Manager to assure that the geonet has been protected from ultraviolet light exposure, precipitation or other inundation, and dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

B. Contractor shall designate each roll with a roll number (identification code) which is consistent with the layout plan. The rolls shall be positioned on the site as shown on the approved layout drawings. Instructions on boxes or wrapping containing the geotextile materials shall be followed to assure that rolls are unrolled in the proper direction.

3.3 MATERIAL QUALITY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the manufacturer certifying that the geosynthetic rolls meet or exceed specified requirements to the Construction Manager for approval prior to deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

• ASTM D5199	4 per roll
• ASTM D792 or D1505	1 per batch
• ASTM D4595	1 per 40,000 ft^2
• ASTM D1238	1 per batch
• ASTM D1603	1 per batch

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.

2. The Geosynthetic CQA Consultant shall obtain samples and forward them to a laboratory designated by the Construction Manager.

3. Tests shall be performed to determine Density (ASTM D792), Thickness (ASTM D5199) and Tensile Strength (ASTM D751) and Transmissivity (ASTM D4716).

4. The sample shall be across the entire width of the roll excluding the first three (3) feet, and shall be cut three (3) feet long by width roll.

5. Samples shall be 3 feet long by roll width. Machine direction shall be marked on sample with an arrow.

3.4 GEONET SEAMS AND OVERLAPS

A. The geonet shall be overlapped at least 4 inches on downslope seams and joined by colored plastic ties every 5 feet.

B. On transverse (horizontal) seams the geonet shall be overlapped 12 inches and joined by colored plastic ties every 12 inches. No horizontal seams will be allowed on slopes greater than 6:1.

C. Metallic devices are not allowed.

D. Seams shall be tied continuously through the anchor trenches and toe drains every 12 inches.

E. Unless prior approval is obtained, no horizontal seams shall be allowed on side slopes.

F. In the event horizontal seams on side slopes can not be avoided, adjacent rolls shall be tied every 6 inches.

3.5 GEONET REPAIR

A. Any holes or tears in geonet shall be repaired as follows: A patch made from same geonet material shall overlap the undamaged geonet a minimum of 12 inches on all sides and tied every 6 inches.

END OF SECTION 02246

ATTACHMENT 12

TECHNICAL SPECIFICATION 02244 (GEOTEXTILE)

SECTION 02242

GEOTEXTILE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Storage, handling, and installation of geotextile.

1.2 REFERENCES

A. ASTM D1117 - Methods of Testing Nonwoven Fabrics.

B. ASTM D5199 - Method for Measuring Thickness of Textile Materials.

C. ASTM D5261 - Test Method for Mass Per Unit Area (Weight) of Nonwoven Fabric.

D. ASTM D3786 - Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.

E. ASTM D4439 - Terminology for Geosynthetics.

F. ASTM D4491 - Test Methods for Water Permeability of Geotextiles by Permittivity.

G. ASTM D4533 - Test Method for Trapezoid Tearing Strength of Geotextiles.

H. ASTM D4632 - Test Methods for Breaking Load and Elongation of Geotextiles (Grab Method).

I. ASTM D4751 - Test Method for Determining Apparent Opening Size of a Geotextile.

J. ASTM D4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

K. ASTM D4873 - Standard Guide for Identification, Storage and Handling of Geotextiles.

1.3 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement, transport, stockpiling or use.

3. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

4. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

5. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by an Illinois licensed surveyor shall be submitted within 1 day of receipt.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the product.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of superintendent to be assigned to the project including dates/duration of employment.

2. A list of personnel to be performing field seaming operations with pertinent experience information.

3. All geosynthetic quality control certificates.

D. Contractor shall submit all material and workmanship warranties for the geotextile installation.

1.4 TESTING

A. Contractor shall retain the services of an independent testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

PART 2 PRODUCTS

2.1 GENERAL

A. Contractor shall furnish materials whose "Minimum Average Roll Values" (MARV), as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria listed below.

B. Products shall be comprised of polymeric yarns of fibers oriented into a stable network which retains its relative structure during handling, placement and long-term service.

2.2 GEOTEXTILE

A. For filtration, cushion, separation and protection purposes, the geotextile shall consist of staple fiber needle-punched, nonwoven, polypropylene fabric where shown on the Drawings. The following minimum fabric properties are required:

GEOTEXTILE PROPERTIES			
Property	**Standard**	**MARV**	**Units**
Mass per Area	ASTM D 5261	16	oz/yd^2
Grab Strength	ASTM D 4632	380	lbs
Elongation	ASTM D 4632	60	%
AOS	ASTM D 4751	100	U.S. Sieve
Permittivity	ASTM D 4491	0.7	sec^{-1}
Trapezoidal Tear Strength	ASTM D 4533	145	lbs
Burst Strength	ASTM D 3786	750	psi
Puncture Strength	ASTM D 4833	240	lbs

2.3 MANUFACTURERS

A. Synthetic Industries

B. Approved Equal

PART 3 EXECUTION

3.1 INSTALLATION

A. Geotextile storage, handling and installation shall be the responsibility of the Contractor. Any damaged or unacceptable material shall be replaced at no additional cost to the Owner. During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings.

B. Geotextile rolls shall be handled in such a way that they are not damaged.

C. Geotextile shall be securely anchored and then rolled in such a manner as to continually keep the geotextile sheet in tension.

D. Geotextile shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

E. If white colored geotextile is used, precautions shall be taken against "snow blindness" of personnel.

F. Contractor shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.

G. Geotextile shall not be exposed to precipitation prior to being installed. Wrappings protecting geotextile rolls shall be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, the geotextile shall not be exposed to direct sunlight for more than 15 days (unless otherwise approved by the Construction Manager).

H. Contractor shall seam geotextile rolls by either overlapping, sewing or other methods approved by the Construction Manager.

I. At a minimum, the Contractor shall use the following seaming techniques at the specified locations:

Location	Method of Seaming
• Side Slopes of Lining System	Sewn
• Over Primary Collection System	Sewn
• Fabric Wrapped Around Sumps and Gravel Drain	Overlapped or sewn
• Beneath Tracked-in-Place Soil	Sewn
• Above Capillary Break Layer	Sewn
• Beneath Cover System Geomembrane	Overlapped or sewn
• Above Cover System Geomembrane	Sewn
• Slopes Steeper Than 10 Percent	Sewn
• Slopes Flatter Than 10 Percent	Overlapped or sewn

J. The geotextile seams not sewn shall be overlapped a minimum of 6 inches.

K. Geotextile seams designated as requiring to be sewn shall be continuously sewn with polymeric thread.

1. The thread shall be capable of supplying a seam strength efficiency of 80 percent of the required tensile strength utilizing a Type 401 two-thread chain stitch with a "J" seam.

2. The seam shall have 8 stitches per inch and the stitches shall be a minimum of 2 inches from the fabric edge.

L. Contractor shall pay particular attention at seams such that no soil material is inadvertently inserted beneath the geotextile.

M. Material placement shall be in the direction of the overlap.

N. Soil materials over the geotextile shall be placed in a manner such that the geotextile is not damaged, minimal slippage of the geotextile or underlying layers occurs, and no excess tensile stresses are present in the geotextile.

O. No construction equipment with ground pressure greater than 5 psi shall operate on slopes.

3.2 REPAIRS

A. Holes or tears in the fabric shall be repaired as follows: A fabric patch made from the same geotextile shall be placed over the hole or tear and sewn to the underlying geotextile. Provide a minimum overlap of 24 inches in all directions. Should any tear exceed 10 percent of the width of the roll, that section of the roll shall be removed and replaced.

3.3 QUALITY CONTROL

A. Visual inspections of shipment and storage activities shall be made by the Construction Manager to assure that the fabric has been protected from ultraviolet light exposure, precipitation or other inundation, and dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

B. Contractor shall designate each roll with a roll number (identification code) which is consistent with the layout plan. The rolls shall be positioned on the site as shown on the approved layout drawings. Instructions on boxes or wrapping containing the geotextile materials shall be followed to assure that rolls are unrolled in the proper direction.

3.4 MATERIAL QUALITY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the manufacturer certifying that the geosynthetic rolls meet or exceed specified requirements to the Construction Manager for approval prior to deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

- ASTM D5261 — 4 per roll
- ASTM D4632 — 1 per 50,000 ft^2
- ASTM D4751 — 1 per 50,000 ft^2
- ASTM D4491 — 1 per 50,000 ft^2
- ASTM D4533 — 1 per 50,000 ft^2
- ASTM D3786 — 1 per 100,000 ft^2
- ASTM D4833 — 1 per 100,000 ft^2

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.

2. The Geosynthetic CQA Consultant shall obtain samples and forward them to a laboratory designated by the Construction Manager.

3. Tests shall be performed to determine mass per Area (ASTM D5261), Permittivity (ASTM D4491), and Tensile Strength (ASTM D4632).

4. The sample shall be across the entire width of the roll excluding the first three (3) feet (ft), and shall be cut three (3) ft long by width roll.

5. Samples shall be 3 ft long by roll width. Machine direction shall be marked on sample with an arrow.

3.5 PLACEMENT OF EARTHEN MATERIALS OVER GEOTEXTILE

A. The Contractor shall place all earthen materials located on top of geotextile in such a manner as to ensure:

1. No damage of geotextile.

2. Minimal slippage of geotextile on underlying layers.

3. No excess tensile stresses in geotextile.

B. Place materials over geotextile by pushing material out over geotextile ahead of equipment in 12-inch thick minimum lifts.

C. On sideslopes, earthen material placement shall begin at toe of slope and proceed upslope to top of slope.

D. Equipment used to place earthen material over the geotextile shall have a maximum contact pressure of 5 lbs/sq inch on earthen material.

E. Thickness of earthen material over geotextile shall be 12 inches or more before equipment used to place earthen material shall be permitted to cross areas where geotextile has been installed.

F. Thickness of cover material over the top geotextile shall be 2 ft before vehicles with contact pressure greater than 8 lbs/sq inch shall be permitted to cross areas where geotextile has been installed.

END OF SECTION 02242

ATTACHMENT 13

TECHNICAL SPECIFICATION 02244 (GEOMEMBRANE)

SECTION 02244

GEOMEMBRANE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. The Contractor shall furnish all material, labor and equipment for the installation of the geomembrane as specified herein and as shown on the Drawings, and shall install the geomembrane and other geosynthetic components of the cover system in close coordination with the Construction Manager.

1.2 REFERENCES

A.	ASTM D 638 -	Test Method for Tensile Properties of Plastics.
B.	ASTM D 792 -	Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.
C.	ASTM D 1004 -	Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
D.	ASTM D 1204 -	Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.
E.	ASTM D 1238, Condition E -	Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
F.	ASTM D 1505 -	Test Method for Density of Plastics by the Density - Gradient Technique.
G.	ASTM D 1603 -	Test Method for Carbon Black in Olefin Plastics.
H.	ASTM D 1693 -	Test Method for Environmental Stress-Cracking of Ethylene Plastics.
I.	ASTM D 4339 -	Terminology for Geosynthetics.
J.	ASTM D 4437 -	Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

K. ASTM D 4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

L. ASTM D 4885 - Test Method for Determining Performance Strength of Geomembranes by Wide Strip Tensile Method

M. ASTM D 5199 - Test Method for Measuring Thickness of Plastics.

N. GRI GM 6 - Standard Practice for Pressurized Air Channel Test for Dual Seamed Geomembranes.

O. GRI GM 13 - Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.

1.3 DEFINITIONS

A. Batch: A quantity of resin, usually the capacity of one railcar, used in the fabrication of High Density Polyethylene (HDPE) geomembrane rolls. The finished rolls are identified by a roll number corresponding to the resin batch used.

B. Bridging: Condition existing when the geomembrane is not in contact with the underlying material.

C. Contractor: The party responsible for manufacturing, shipping, field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installing the geomembrane. This responsibility includes the work performed by the Manufacturer and the Installer.

D. Manufacturer: The party responsible for production of any of the various geosynthetic components.

E. Installer: The part responsible for installation of the geosynthetics.

F. Extrudate: HDPE material produced in the form of a rod used by the Contractor to extrusion weld panels of geomembrane together.

G. Geomembrane: Very-low permeability synthetic flexible membrane liner (FML) barrier used to minimize fluid migration.

H. Geomembrane Subsurface: Material surface upon which geomembrane will be placed.

I. Quality Assurance Laboratory (Third Party Laboratory): Party, independent from the Owner, Manufacturer, and Contractor, responsible for conducting laboratory tests on samples of geomembrane obtained at the site.

J. Panel: The unit area of geomembrane, a roll or a portion of a roll, that will be seamed in the field.

K. Panel Layout Drawings: Drawings submitted by the Contractor indicating panel numbers, field seams, and details.

L. Subgrade: Soil material directly below the geomembrane.

1.4 TESTING

A. Contractor shall retain the services of an independent testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Construction Manager prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

1.5 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit the results of conformance testing of the geosynthetic materials selected for interface friction testing for approval within thirty (30) days of contract award.

3. Contractor shall submit prequalification data on each geosynthetic material to the Construction Manager for approval prior to procurement transport, stockpiling or use.

4. Contractor shall submit results of all quality control data and information to the Construction Manager within 1 work day of receipt.

5. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

6. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted written 1 day of receipt.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the products.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of Superintendent to be assigned to the project including dates/duration of employment.

2. Resume of Master Seamer including dates/duration of employment.

3. A list of personnel to be performing field seaming operations with pertinent experience information.

4. All geosynthetic quality control certificates .

5. Certification that the extrudate is comprised of the same resin as the geomembrane to be used.

6. Description of seaming techniques and apparatus to be used.

7. Properties of extrudate to be used.

D. Raw Materials

1. Copy of quality control certificates issued by resin suppliers.

2. Production date(s) of resin.

3. Reports on tests conducted to confirm quality of resin used to manufacture geomembrane rolls assigned to considered facility. Report shall indicate compliance with requirements in Part 2 – Products of this Specification.

4. Statement that no reclaimed polymer is added to resin during manufacture of actual geomembrane to be used in this project.

E. Geomembrane Roll Production: Copy of quality control certificates indicating compliance with requirements of Part 2 of this Specification.

F. Installation Panel Layout Drawing identifying placement patterns and seams, both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from the Drawings. Layout shall be drawn to scale and shall be adequate for use as the construction plan, and shall include information such as dimensions, panel numbering, and installation details. The Engineer shall review all Panel Layout Drawings prior to installation. Panel Layout Drawings, as prepared by the Contractor and reviewed by the Engineer, shall be submitted to USEPA 30 days prior to liner installation.

G. Installation Schedule.

H. During installation the Contractor shall submit:

1. Quality control documentation recorded during installation.

2. Daily subgrade acceptance for each area to be covered signed by the Installer.

I. Warranties:

1. Submit a material warranty signed by the geomembrane manufacturer. The material warranty shall be against manufacturing defects and workmanship, and against deterioration due to ozone, ultraviolet, and other exposure to the elements, for a period of one year from final acceptance. The material warranty shall be limited to replacement of material, and shall not cover installation of replacement geomembrane.

2. Submit workmanship warranty signed by the geomembrane installer. The installer shall warrant the geomembrane system to be installed to be free of defects in workmanship for a period of 2 years following the date of final acceptance of the work under this Contract. The workmanship warranty shall cover installation of replacement geomembrane.

J. Submittals Required for Project Closeout

1. <u>Record Drawing</u>: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the

identification and location of each repair, cap strip, penetration, boot, and sample taken from the installed geomembrane.

2. Quality Control Record: Submit copies of all material and seam test results. Each test shall be identified by date of sample, date of test, sample location, name of individual who performed the test, and standard test method used.

3. Weld Test Summary Report: Submit copies of report showing normal distribution of all test results, and individual test results identifying the high, low, and average of the five coupon samples in each test.

1.6 QUALIFICATIONS

A. Manufacturer

1. Manufacturer shall have at least 5 years continuous experience in the manufacturing of HDPE geomembrane rolls and experience totaling 2 million sq ft of manufactured HDPE for at least 10 completed facilities.

2. The Manufacturer shall have an internal quality control program that meets standard industry requirements.

B. Installer

1. The Installer shall have at least 5 years continuous experience in the installation of HDPE geomembrane and experience totaling 2 million sq ft of installed HDPE geomembrane for at least 10 completed facilities.

2. The Installer's Superintendent shall have previously managed at least two installation projects which entail at least 100,000 ft^2 of HDPE geomembrane.

3. Personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one "Master Seamer" shall have experience seaming a minimum of 1 million sq. ft. of HDPE geomembrane using same type of seaming apparatus in use on-site. The "Master Seamer" shall have experience seaming textured and non-textured material and shall provide direct supervision, as required, over less experienced seamers.

C. Quality Assurance Program

Manufacturer/Contractor shall agree to participate in and conform with all items and requirements of these Specifications and the Construction Quality Assurance Manual for the Installation of Geosynthetic Components.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver and store geomembrane in strict accordance with the manufacturer's recommendations.

B. Geomembrane delivered to the site shall be inspected for damage, unloaded, and stored with a minimum of handling. The storage area shall be such that materials are protected from mud, soil, dirt, and debris. Geomembrane may be stored directly on prepared level surface, but no more than three rolls in height.

C. The Contractor shall be responsible for coordination and payment of shipping, unloading, storing, handling and installing geomembrane.

D. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes slings, spreader bars or an equipment bucket which has been properly protected.

E. Damaged or unacceptable materials shall be replaced at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. GSE Lining Technology, Inc. (Gundle/SLT), Houston, Texas.

B. Approved Equal

2.2 GEOMEMBRANE

A. The geomembrane shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, as satisfactorily demonstrated by prior use.

B. The geomembrane shall be high-density polyethylene (HDPE) with a UV-stabilized surface and contain no plasticizers, fillers, chemical additives, reclaimed polymers, or extenders.

C. Approximately 2 percent carbon black shall be added to the resin for ultraviolet resistance.

D. The only other compound elements shall be anti-oxidants and heat stabilizers, of which up to 1.5 percent total, as required for manufacturing, may be added.

E. The geomembrane shall be supplied as a single-ply continuous sheet with no factory seams. Rolls shall have a minimum width of 22 feet.

F. The roll length shall be maximized to provide the largest manageable sheet for the fewest field seams.

G. All rolls shall be identified with a unique roll number printed on a label affixed to the inside and outside of the roll.

H. Each roll shall have a continuous identification printed on the membrane showing manufacturer, thickness, material, and date of manufacture.

I. HDPE geomembrane shall meet the following requirements:

HDPE GEOMEMBRANE - SMOOTH

Properties	**Test Method**	**Requirements**	**Testing Frequency (minimum)**
Liner Thickness, mils (nominal)	ASTM D5199	60	Per Roll
Density (g/cc)	ASTM D1505-A	0.94	200,00 lbs
Tensile Properties (min. aveg.) 1. Tensile Strength @ Yield (ppi) 2. Tensile Strength @ Break (ppi) 3. Elongation @ Yield (%) 4. Elongation @ Break (%)	ASTM D638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)	 126 228 12 700	20,000 lbs
Tear Resistance (min. aveg.)	ASTM D1004 Die C	42 lbs	45,000 lbs
Dimensional Stability % Change Each direction	ASTM D1204 212 °F 1 hr	± 2	
Stress Crack Resistance (hrs)	ASTM D5397	200	Per Batch
Puncture Resistance (min. aveg.)	ASTM 4833	108 lbs	45,000 lbs
Carbon Black Content (%) Carbon Black Dispersion	ASTM D1603 ASTM D5596	2 A1, A2 and B1	20,000 lbs 45,000 lbs
Oxidative Induction Time (OIT) (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.)	 ASTM D3895 ASTM D5885	 100 minutes 400 minutes	200,000 lbs
Oven Aging at 85° (a) Standard OIT (min. aveg.) - % retained after 90 days -or-	ASTM D5721 ASTM D3895	55%	Per Batch

Properties	Test Method	Requirements	Testing Frequency (minimum)
(b) High Pressure OIT (min. aveg.) - % retained after 90 days	ASTM D5885	80%	
UV Resistance (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.) - % retained after 1600 hrs	GM 11 ASTM D3895 ASTM D5885	 Not Recommend 50%	Per Batch

HDPE GEOMEMBRANE - TEXTURED

Properties	Test Method	Requirements	Testing Frequency (minimum)
Liner Thickness, mils (nominal)	ASTM D5199	60	Per Roll
Density (g/cc)	ASTM D1505-A	0.94	200,00 lbs
Asperity Height (mils)	GM 12	10	Per Roll
Tensile Properties (min. aveg.) 1. Tensile Strength @ Yield (ppi) 2. Tensile Strength @ Break (ppi) 3. Elongation % Yield (%) 4. Elongation @ Break (%)	ASTM D638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)	 126 90 12 100	20,000 lbs
Tear Resistance (min. aveg.)	ASTM D1004 Die C	42 lbs	45,000 lbs
Low Temperature Brittleness °F	ASTM D746-B	-107 (max)	---
Dimensional Stability % Change Each direction	ASTM D1204 212 °F 1 hr	± 2	---
Stress Crack Resistance (hrs)	ASTM D5397	200	Per Batch
Puncture Resistance (min. aveg.)	ASTM 4833	90 lbs	45,000 lbs
Carbon Black Content (%) Carbon Black Dispersion	ASTM D1603 ASTM D5596	2 A1, A2 and B1	20,000 lbs 45,000 lbs
Oxidative Induction Time (OIT) (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.)	 ASTM D3895 ASTM D5885	 100 minutes 400 minutes	200,000 lbs
Oven Aging at 85° (a) Standard OIT (min. aveg.) - % retained after 90 days	ASTM D5721 ASTM D3895	--- 55%	Per Batch

Properties	Test Method	Requirements	Testing Frequency (minimum)
-or- (b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D5885	80%	
UV Resistance (a) Standard OIT (min. ave.) -or- (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs	GM 11 ASTM D3895 ASTM D5885	Not Recommend 50%	Per Batch

J. Geomembrane shall not have striations, roughness, pinholes or bubbles on the surface

2.3 EXTRUDATE

A. Extrudate shall be made from the same resin as the geomembrane.

B. Additives shall be thoroughly dispersed in the extrudate.

C. Additives shall be free of contamination by moisture or foreign matter.

2.4 FIELD SEAMS

A. Approved processes for seaming are extrusion welding and fusion double seam welding. Fusion double seam welding is the preferred method for joining long, straight seams. Extrusion welding is the preferred seaming method in areas such as corners, sumps, pipe penetrations, tear repairs and cap strips where fusion double seam welding is not feasible.

B. Only apparatus which has been specifically approved by make and model shall be used.

C. Proposed alternate processes shall be documented and submitted by the Contractor for approval by the Construction Manager.

D. Resin used for extrusion welding shall be produced from same resin type as geomembrane.

E. Physical properties of the welding resin shall be the same as those of the resin used in the geomembrane.

F. Geomembrane seams shall meet following requirements:

HDPE GEOMEMBRANE
SEAM PROPERTIES

Property	Qualifier	Unit	Specified Value	Test Method
Shear Strength (at yield point)	minimum	lb/in. width	120 and FTB[1]	ASTM D 4437
Peel Adhesion Fusion	minimum	lb/in. width	100 and FTB[1]	ASTM D 4437
Peel Adhesion Extrusion	minimum	lb/in. width	100 and FTB[1]	ASTM D 4437

Note:

[1] = Film Tear Bond (FTB) is defined as failure of one of the sheets by tearing, instead of separating from the other sheet at the weld interface area (i.e., sheet fails before the weld fails).

2.5 EQUIPMENT

A. Welding Equipment:

1. The Contractor shall provide welding equipment equipped with gauges showing temperatures at the nozzle (extrusion welder) or at the wedge (wedge welder), or have the equipment capable of measuring the temperature of the nozzle (hot air).

2. Equipment shall be maintained in adequate number to avoid delaying work, and shall be supplied by a power source capable of providing constant voltage under a combined-line load.

3. Electric generator shall not be placed on the membrane, unless otherwise approved by the Construction Manager.

B. Field Tensiometer:

1. The Contractor shall provide a tensiometer for onsite shear and peel testing of geomembrane seams.

2. The tensiometer shall be motor driven and have jaws capable of traveling at a measured rate of two (2) inches per minute.

3. The tensiometer shall be in good working order, built to ASTM specifications, and accompanied by evidence of recent calibration.

4. It shall be equipped with a gauge that measures the force in unit pounds exerted between the jaws and have a digital readout.

C. Punch Press:

1. The Contractor shall provide a punch press for the onsite preparation of specimens for testing.

2. The press shall be capable of cutting specimens in accordance with ASTM D4437.

D. Vacuum Box:

1. The Contractor shall provide a vacuum box for onsite testing of geomembrane seams.

2. The vacuum box shall have a transparent viewing window on top and a soft, closed-cell neoprene gasket attached to the bottom.

3. The housing shall be rigid and equipped with a bleed valve and vacuum gauge.

4. A separate vacuum source shall be connected to the vacuum box.

5. The equipment shall be capable of inducing and holding a vacuum of 5 psi.

E. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of a manual or motor driven air pump equipped with a pressure gauge.

2. The equipped shall be capable of generating and sustaining pressure over 25 psi.

3. Equipment shall be mounted on a cushion to protect the geomembrane.

4. It shall be equipped with a rubber hose with fittings and connections along with a sharp hollow needle.

5. Other pressure feed devices with a gauge and an accuracy of one (1) psi may be used, as approved by the Construction Manager.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

A. Contractor shall remove all gravel and other protrusions from geomembrane subgrade. Grade stakes or hubs shall also be removed from subgrade prior to geomembrane placement.

B. Special care must be taken to maintain prepared soil surface. Soil surface shall be observed daily to evaluate desiccation cracking. Damage to subgrade shall be repaired to the satisfaction of the Construction Manager.

C. Do not place geomembrane in area which has become softened by precipitation.

D. Contractor shall certify to the Construction Manager in writing daily that the surface on which the geomembrane will be placed is acceptable.

3.2 PREPARATIONS

A. Damage to geomembrane subsurface during geomembrane deployment or other activities shall be repaired prior to installation.

B. Subgrade shall be smooth and consist of clean fine graded material free of rocks, protrusions, sharp objects and deleterious material of any kind.

C. Edges of excavations and grade changes should be rounded to a minimum six (6) inch radius.

D. Geomembrane material may be placed when air temperature is greater than 35°F, and increasing or less than 100°F, unless other limits are approved, in writing, by the Construction Manager.

E. Do not place during precipitation in presence of excessive moisture (e.g., fog, dew), in area of ponded water, or during excessive winds.

3.3 ANCHOR TRENCH

A. The anchor trench shall be excavated by the Contractor to the lines and grades shown on the Plans prior to geomembrane deployment.

B. Contractor shall remove all loose soil from the anchor trench prior to geomembrane deployment No loose soil shall be allowed to underlie the geomembrane.

C. Excavated surface of the anchor trench shall be protected by the Contractor from desiccation or excessive moisture.

D. Contractor shall not damage geomembrane during backfill placement in anchor trench.

3.4 DEPLOYMENT

A. Each panel deployed shall be assigned a simple and logical identifying code consistent with the submitted panel layout drawings.

B. No more panels shall be deployed in one day that can be welded during that same day.

C. Tack welding may be acceptable as a temporary measure; however, tack welded panels shall not be left overnight.

D. Panels shall be shingled on all slopes such that the upper panel of a cross-seam is overlapped above the lower panel.

E. Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope) anchored securely and deployed down the slope in a controlled manner. Panels shall not be pulled up the slope.

F. Ballast, that will not damage the geomembrane, shall be used to prevent uplift due to wind. Methods used shall minimize wrinkles.

G. Contractor shall securely anchor the geomembrane on a daily basis to prevent "pull-out" from the anchor trench with materials and methods approved by the Construction Manager. Special attention should be given to geomembrane shrinkage overnight.

H. Folds shall be immediately removed on all installations.

I. Personnel walking on the geomembrane shall not engage in activities or wear types of shoes, that could damage the geomembrane.

J. Smoking shall not be permitted while working on the geomembrane.

K. Vehicular traffic directly on the geomembrane shall not be permitted.

L. Equipment shall not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or any other means.

M. The geomembrane surface shall not be used as a work area, for preparing patches, storing tools and supplies, or other uses. If needed, a protective cover may be spread out as a work surface.

N. Material shall be placed in a manner to allow for geomembrane shrinkage, contraction and to avoid bridging.

3.5 SEAMING

A. Seam Layout

1. In general, orient end seams (traverse) parallel to line of maximum slope, i.e., oriented along, not across, slope. In corners and odd-shaped geometric locations, minimize numbers of field seams.

2. Seam coding system shall be compatible with panel coding system.

3. During welding operations, at least one Master Seamer shall be present and shall provide supervision over other welders.

4. The surface of the geomembrane shall be clean of grease, moisture, dust, dirt, debris, or other foreign material.

5. Solvents or adhesives shall not be used unless the product is approved in writing by the Construction Manager.

6. Panels shall overlap by a minimum of four (4) inches for all welds.

7. Seams shall be welded to the outside edge of panels placed under anchor berms or in anchor trenches.

8. Fishmouths or wrinkles at seam overlaps shall be cut to achieve a flat overlap.

9. The cut fishmouths or wrinkles shall be extrusion welded or patched where the overlap is more than three (3) inches.

10. When there is less than three (3) inches overlap, an oval or round patch extending a minimum of six (6) inches beyond the cut in each direction shall be used.

11. Seams shall be welded only when ambient temperature is between 35°F and 100°F as measured 6 inches above the geomembrane surface unless other limits are approved in writing by the Engineer.

B. Extrusion Seaming

1. Adjacent panels shall be tack bonded together using procedures that do not damage the geomembrane, allow required tests to be performed, and are not detrimental to final seaming.

2. Welding apparatus shall be free of heat-degraded extrudate before welding.

3. The geomembrane surface shall be abraded a maximum of 1/4 inch beyond the weld bead area, using a disc grinder, or equivalent, not more than one hour before extruding seam.

4. The ends of all seams, which are more than five (5) minutes old, shall be ground when restarting the weld.

5. Grinding depth shall not exceed ten (10) percent of the liner thickness.

6. Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.

7. Provide documentation of extrudate to the Construction Manager and certify that extrudate is compatible with specifications and is comprised of same resins as geomembrane.

8. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

9. Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from barrel.

10. Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.

C. Fusion Seaming

1. Welding apparatus shall be automated, vehicular-mounted, and equipped with gauges indicating applicable temperatures and pressures.

2. Edges of cross seams shall be ground smooth including top and bottom prior to welding.

3. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

D. Trial Welds

1. Trial welds shall be performed on geomembrane samples to verify welding equipment operations and performance of seaming methods and conditions.

2. Minimum of two (2) trial welds per day or shift per welding apparatus shall be made, one made prior to the start of work and one completed at mid shift.

3. Welds shall be made under the same surface and environmental conditions as the production welds (i.e., in contact with geomembrane subsurface and similar ambient temperature).

E. Trial Weld Testing

1. Sample shall be at least three (3) feet long and two (2) feet wide with the seam centered lengthwise.

2. Three (3), 1-inch wide test strips shall be cut from the trial weld.

3. Each of the specimens shall be tested in the field by the Contractor for peel and shear using a digital tensiometer.

4. Remaining sample shall be retained for future testing.

5. A trial weld specimen shall pass when the results are achieved for both peel and shear tests as shown herein. For double-wedge welding, both welds shall be individually tested and both shall be required to pass in peel.

6. Seaming apparatus or seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive successful full trial seams are achieved

3.6 MATERIAL QUALTY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the geomembrane manufacturer certifying that the geomembrane blankets and/or rolls meet or exceed specified requirements to the Construction Manager for approval prior to geomembrane deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

1. Raw material for geomembrane and extrudate rod or bead:

• ASTM D792	1 per batch
• ASTM D1238, Condition E	1 per batch
• ASTM D746	1 per batch

2. Geomembrane Roll:

• ASTM D5199	Continuous or 25 per sheet
• ASTM D638	1 per 50,000 ft^2
• ASTM D1505-A	1 per 50,000 ft^2
• ASTM D1004, Die C	1 per 50,000 ft^2
• ASTM D4833	1 per 50,000 ft^2
• ASTM D1603	1 per 100,000 ft^2

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.

2. The Geosynthetic CQA Consultant shall obtain samples and forward them to a laboratory designated by the Construction Manager.

3. Tests shall be performed to determine geomembrane Density (ASTM D1505), Thickness (ASTM D5199) and Tensile Strength (ASTM D 638).

4. The sample shall be across the entire width of the roll excluding the first three (3) feet, and shall be cut three (3) feet long by width of roll.

5. Within 30 days of contract award, Contractor shall submit the results of the following interface shear tests:

   - Smooth HDPE - Compacted Soil
   - Smooth HDPE - Geonet
   - Textured HDPE - Geonet
   - Textured HDPE - Geosynthetic Clay Liner

   These tests shall be performed in accordance with ASTM D 5321.

3.7 CONSTRUCTION QUALTY EVALUATION

A. Contractor shall non-destructively test all field seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), or other approved methods. Non-destructive testing shall be carried out daily as the seaming progresses and not at completion of all seaming or at the completion of the day.

B. Vacuum testing shall conform to the following requirements:

1. The equipment shall consist of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, a soapy solution and an applicator.

2. Testing shall conform to the following procedure: Brush soapy solution on geomembrane (approximately 12" x 36"). Place vacuum box over the wetted seam area. Close bleed valve and open vacuum valve, and ensure that a leak-tight seal is created. Apply a vacuum of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than fifteen (15) seconds. All areas where soap bubbles

appear shall be marked and repaired as described in this Section. If no bubble(s) appear after 15 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three (3) inches overlap, and repeat process.

C. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of an air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining pressure over twenty-five (25) psi and mounted on a cushion to protect the geomembrane, a rubber hose with fittings and connections, a sharp hollow needle, or other approved pressure feed device, and a gauge with an accuracy of one (1) psi.

2. Testing shall conform to the following procedure: Seal both ends of the seam to be tested. Insert needle or other approved pressure-feed device into the channel created by the double-wedge weld. Energize the air pump to a minimum pressure of twenty-five (25) psi, close the valve, and sustain the pressure for at least five (5) minutes. If pressure loss exceeds two (2) psi or does not stabilize, locate faulty area and repair as described in this Section. Puncture opposite end of the seam to release air. If blockage is present, locate and test seam on both sides of blockage. Remove needle or other approved pressure-feed device and seal penetration holes by extrusion welding.

D. Spark Testing: For those extrusion welded seams which are unable to be tested by a vacuum box, the spark test method shall be used with a 24-gauge copper wire placed 1/8" under the top sheet overlap and a Holiday detector operating at 20,000 volts.

E. Field seam locations that cannot be non-destructively tested by the Contractor as determined by the Construction Manager shall be cap-stripped using the same materials as the underlying geomembrane.

3.8 DESTRUCTIVE TESTING

A. Sample Location

1. Collect destructive test samples at a minimum frequency of one test per 500 feet of seam length. Test locations shall be determined during seaming. Locations may be prompted by appearance of excess heating, contamination, offset welds, or suspected defect. The Construction Manager shall be responsible for choosing the locations. The Construction Manager shall not notify the Contractor in advance of selecting locations where seam samples will be taken.

2. The Contractor shall cut samples at locations designated by the Construction Manager as the seaming progresses to obtain-laboratory test results before the geomembrane is covered. The Construction Manager shall number each sample and mark the sample number and location on the panel layout drawing.

3. The Contractor shall immediately repair all holes in the geomembrane resulting from destructive sampling. The continuity of the repair shall be vacuum tested in accordance with this Section.

4. The destructive sample shall be eighteen (18) inches wide by forty-two (42) inches long with the seam centered lengthwise. The sample shall be cut into three (3) equal parts for distribution to the Contractor, the Laboratory and the Owner for archiving.

B. Laboratory Testing

1. Samples shall be tested in peel and shear (ASTM D4437).

2. All tests shall exhibit a Film Tearing Bond type of separation in which the geomembrane material tears before the weld.

3. At least five (5) coupons shall be tested by each test method.

4. Four (4) of the five (5) coupons shall meet the minimum requirements stated herein.

5. Test results shall be provided verbally within 24 hours after receiving samples, and within three (3) days in written form.

C. Destructive Test Failure

1. One of two options shall be followed:

   a. Option 1: Reconstruct the seam between any two (2) passed test locations.

   b. Option 2: Trace the weld to an intermediate location at least ten (10) feet minimum or to where the seam ends, in both directions from the location of the failed test to collect a destructive test sample at both locations. Check the next seam welded using the same welding device if required to obtain an additional sample (i.e., if one side of the seam is less than ten (10) feet long). Bounding laboratory samples shall be taken, and destructive testing shall be performed per this Section. If the bounding samples pass, then the seam shall be reconstructed between the test sample locations. If any additional samples fail, then the process shall be repeated to establish the zone in which the seam shall be reconstructed.

2. Reconstruction methods shall include extrusion welding of previously wedge welded seams, cap stripping of seam, or replacing seam with a new one (1) foot wide panel and welding in place.

D. Acceptable seams shall be bounded by two locations from which samples have passed destructive tests. For reconstructed seams exceeding fifty (50) feet, a sample taken from within the reconstructed seam shall also pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were welded by the same welder and welding apparatus or were welded during the same shift.

3.9 DEFECTS AND REPAIRS

A. The geomembrane shall be examined for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

B. The geomembrane surface shall be clean at the time of the examination.

C. Each suspect location shall be repaired and non-destructively tested.

D. Geomembrane shall not be covered at locations which have been repaired until test results with passing values are available.

E. Damaged geomembrane shall be removed and replaced with acceptable geomembrane if damage cannot be satisfactorily repaired.

F. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test shall be repaired.

G. The Contractor shall be responsible for repair of damaged or defective areas. One of the procedures listed below shall be recommended by the Contractor and approved by the Engineer:

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

2. Abrading and Re-welding: Used to repair small seam sections (less than twelve (12) inches long).

3. Spot Welding: Spot welding is not allowed.

4. Capping: Used to repair large lengths of failed seams.

5. Removing unsatisfactory material and replacing with new material.

H. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.

1. Patches or caps shall extend at least six (6) inches beyond the edge of the defect, and all corners of material to be patched and the patches shall be rounded to a radius of at least four (4) inches.

2. The geomembrane below large caps shall be cut to avoid water or gas collection between the two sheets.

I. Repairs shall be verified using the following procedure:

1. Each patch repair shall be non-destructively tested using methods specified in this Section.

2. Destructive testing may be required at the discretion of the Construction Manager.

3.10 GEOMEMBRANE ACCEPTANCE

A. Contractor shall retain all ownership and responsibility for the geomembrane until final acceptance by the Construction Manager.

B. Construction Manager will accept the geomembrane installation when the installation is finished and all required documentation from the Contractor has been received and approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

3.11 MATERIALS IN CONTACT WITH GEOMEMBRANE

A. General

1. Carefully install materials in contact with geomembrane surfaces to minimize damage potential.

2. Clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane to each appurtenance shall have lifespan equal to or exceeding geomembrane's.

B. Pipes and Other Appurtenances

1. Install geomembrane around appurtenances, such as pipes, protruding through geomembrane as shown in Plans. Unless otherwise specified, initially install geomembrane sleeve or apron around each appurtenance prior to geomembrane installation.

2. After material is placed and seamed, complete final field seam connection between appurtenance sleeve or apron and geomembrane. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geomembrane can be accommodated.

3. Extreme care shall be taken while seaming around appurtenances because both nondestructive and destructive seam testing might not be feasible. Do not damage geomembrane while making connections to appurtenances.

END OF SECTION 02244

ATTACHMENT 14

INITIAL INVESTIGATION LAB TEST DATA SUMMARY

Project : 23-99STL022.01 File: Indx1.xls TABLE 1

SOLUTIA
LABORATORY TESTING DATA SUMMARY

BORING NO.	SAMPLE NO.	DEPTH (ft)	IDENTIFICATION TESTS WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLAS. IND.	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	TOTAL UNIT WEIGHT (pcf)	STRENGTH Type Test	PEAK DEVIATOR STRESS (tsf)	AXIAL STRAIN @ PEAK STRESS (%)	CONSOL. INITIAL CONDITIONS VOID RATIO (-)	SATURATION (%)	REMARKS
GB-1		1-2.5	13.5		np		SM								
GB-1		4.35-4.7	20.4				ML		106.3	UC	0.52	3.2			
GB-1		5.05-5.4	18.7				ML								
GB-1		5.4-5.75	18.3				ML								
GB-1		6-8							111.3						
GB-1		6.15	21.8												
GB-1		6.45	28.2				ML		115.0	UC	0.48	7.7			
GB-1		6.75	32.5												
GB-1		7.3	35.3												
GB-1		7.55	32.3		np		ML		113.9				1.000	89.0	
GB-1		9-10.5	32.6				CL-ML								
GB-1		14-15.5	36.6				SM	43.2							
GB-1		19-20.5	32.3				SP-SM	6.2							
GB-2		1-3							112.0						
GB-2		1.1	22.3												
GB-2		1.35	22.6				ML		116.0	UC	0.95	4.0			
GB-2		1.65	19.4												
GB-2		5.3-5.65	28.1	34	24	10	ML								
GB-2		6-7.5	29.5				CL-ML								
GB-2		9-10.5	25.5				SP-SM	9.1							
GB-2		29-30.5	22.1				SP	3.7							
GB-2		34-35.5	17.9				SP	3.6							
GB-2		49-50.5	21.2				SP	2.1							

Prepared by: CMJ Reviewed by: [illegible] Date: 11/30/1999

TABLE 1 INUED

SOLUTIA

LABORATORY TESTING DATA SUMMARY

BORING NO.	SAMPLE NO.	DEPTH (ft)	IDENTIFICATION TESTS: WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLAS. IND.	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	TOTAL UNIT WEIGHT (pcf)	STRENGTH: Type Test	PEAK DEVIATOR STRESS (tsf)	AXIAL STRAIN @ PEAK STRESS (%)	CONSOL. INITIAL CONDITIONS: VOID RATIO (-)	SATUR-ATION (%)	REMARKS
GB-3		1-3							91.7						
GB-3		1.15	13.5												
GB-3		1.7	6.4												
GB-3		2.25	8.9												
GB-3		7.1-7.45	7.1				SM	18.1							
GB-3		7.45-7.8	6.2				SP								
GB-3		7.8-8.15	21.2				SP								
GB-3		8.15-8.5	8.1				SP		88.9						
GB-3		9-10.5	34.5				SM	48.6							
GB-3		11.5-13	35.5	32	25	7	ML								
GB-3		14-15.5	32.8				CL-ML								
GB-3		19-20.5	26.9				SP	4.8							
GB-3		44-45.5	18.8				SP	2.1							
P2-1		1-2.5	31.2				CL								
P2-1		4-5.5	36.0	60	20	40	CH								
P2-1		6-7.5	36.4				CL-ML								

Note: (1) USCS symbol based on visual observation unless Sieve and Atterberg limits reported.

Prepared by: CMJ Reviewed by: [signature] Date: 11/30/1999

ATTACHMENT 15

TECHNICAL SPECIFICATION 02245
(GEOSYNTHETIC CLAY LINER)

SECTION 02245

GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes the requirements for procurement, transportation, storage, handling, installation, and protection of geosynthetic clay liner (GCL).

1.2 REFERENCES

A. American Society for Testing Materials (ASTM)

1. ASTM E 496 - Test Method for Plate Water Absorption of Cohesive Soils.

2. ASTM D 4643 - Test Method for Determination of Water Content of Soil (modified)

3. ASTM D 5084 - Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter (modified).

4. ASTM D 5321 - Test Method for Determining the Coefficient of Soil an Geosynthetic or Geosynthetic Friction by the Direct Shear Method.

5. ASTM D 3776 - Test Method for Mass Per Unit Area of Textiles.

6. ASTM D 4632 - Test Method for Grab Breaking Load and Elongation of Geotextiles.

7. ASTM D 3786 - Test Method for the Mullen Burst Strength of Textiles.

B. U.S. Pharmacopoeia - National Formulary XVII, page 1210

1. USP-NF-XVII - Test Method for the Free Swell of Bentonite Clay.

C. Geosynthetics Research Institute, Drexel University

1. GRI-GCL-1 - Test Method for the Confined Swell of Geosynthetic Clay Liners.

1.3 SUBMITTALS

A. Pre-installation: Submit the following to the Engineer for approval prior to GCL deployment.

1. Manufacturer's specification for GCL which includes properties contained in Tables 1 and 2.

2. Written certification that the GCL meets the properties listed in Tables 1 and 2.

3. Written certification that GCL manufacturer has continuously inspected GCL for the presence of needles and found GCL to be needle-free.

4. Written certification from the GCL manufacturer that the bentonite will not shift during transportation or installation thereby causing thin spots in the body of the GCL.

5. Quality control certificates signed by a responsible entity of the GCL manufacturer. Each quality control certificate shall include roll identification numbers, and results of quality control tests. At a minimum, results shall be given for tests and corresponding methods specified in Tables 1 and 2.

6. Written certification that sealing material is made of same natural sodium bentonite as the GCL.

B. Installation: Submit the following as installation proceeds: Subgrade surface acceptance, signed by the Contractor for each area that will be covered directly by GCL.

1.4 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping

1. GCL shall be supplied in rolls wrapped individually in relatively impermeable and opaque protective covers.

2. GCL rolls shall be marked or tagged with the following information:

   a. Manufacturer's name

   b. Product identification

   c. Roll number

   d. Roll dimensions

e. Roll weight

B. Storage and Protection:

1. The Contractor shall provide on-site storage area for GCL rolls from time of delivery until installation. Rolls of GCL will be stored off the ground from time of delivery until they are installed.

2. After Contractor mobilization, store and protect GCL from dirt, water, ultraviolet light exposure, and other sources of damage.

3. Preserve integrity and readability of GCL roll labels.

PART 2 PRODUCTS

2.1 MATERIALS

A. The active ingredient of the GCL shall be natural sodium bentonite. The bentonite shall be encapsulated between two polypropylene textiles.

B. For side slopes steeper than 7H:1V the GCL shall be needle punched with high strength polypropylene thread to provide internal shear strength reinforcing. The internal shear reinforcing mechanism shall resist failure due to thread pull-out over long-term creep situations.

C. The textiles shall be sufficiently porous to allow bentonite flow-through such that the permeability of the overlap seams is equal to or less than the permeability of the body of the GCL sheet without the addition of granular or paste bentonite.

D. Non-reinforced GCL materials shall have the following minimum properties:

TABLE 1

Test Designation	Test Method	Test Frequency	Report Value
BENTONITE			
Swell Index	ASTM D5890	1 per 50 tonnes	24 ml/2 g min
Moisture Content(%max)	ASTM D4643	1 per 50 tonnes	12 %
Bentonite Mass/Area	ASTM D 5993	40,000 ft^2	0.75 lb/ft^2
Fluid Loss	ASTM D5891	1 per 50 tonnes	18 ml
GEOTEXTILE			
Top layer	ASTM D5261	3.0	oz/sy
Bottom Layer	ASTM D5261	2.5	oz/sy

TABLE 1 (cont'd)

Test Designation	Test Method	Test Frequency	Report Value
GCL Grab Strength	ASTM D 4632	200,000 ft^2	75 lbs
GCL Peel Strength	ASTM D 4632	N/A	N/A
GCL Index Flux	ASTM D 5887	Weekly	$1x10^{-8}$ $m^3/m^2/sec$
GCL Permeability	ASTM D5084	Weekly	$5x10^{-9}$ cm/s
GCL Hydrated Internal Shear Strength	ASTM D 5321	Periodic	50 psf Typical
Internal Friction Angle	ASTM D 6243	Periodic	30 degrees

E. Reinforced GCL material shall have the following minimum properties:

TABLE 2

Test Designation	Test Method	Test Frequency	Report Value
BENTONITE			
Swell Index	ASTM D5890	1 per 50 tonnes	24 ml/2 g min
Moisture Content(%max)	ASTM D4643	1 per 50 tonnes	12 %
Bentonite Mass/Area	ASTM D 5993	40,000 ft^2	0.75 lb/ft^2
Fluid Loss	ASTM D5891	1 per 50 tonnes	18 ml
GEOTEXTILE			
Top layer	ASTM D5261	6.0	oz/sy
Bottom Layer	ASTM D5261	3.1	oz/sy

TABLE 2 (cont'd)

Material Property	Test Method	Test Frequency	Required Values
GCL Grab Strength	ASTM D 4632	200,000 ft^2	90 lbs
GCL Peel Strength	ASTM D 4632	40,000 ft^2	15
GCL Index Flux	ASTM D 5887	Weekly	$1x10^{-8}$ $m^3/m^2/sec$
GCL Permeability	ASTM D5084	Weekly	$5x10^{-9}$ cm/s

Material Property	Test Method	Test Frequency	Required Values
GCL Hydrated Internal Shear Strength	ASTM D 5321	Periodic	500 psf Typical
Internal Friction Angle	ASTM D 6243	Periodic	30 degrees

F. The bentonite shall be continuously adhered to both geotextiles to ensure that the bentonite will not be displaced during handling, transportation, storage and installation, including cutting, patching and fitting around penetrations.

G. The bentonite sealing compound or bentonite granules used to seal penetrations and make repairs shall be made of the same natural sodium bentonite as the GCL and shall be as recommended by the GCL manufacturer.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

A. The Construction Manager shall obtain certification from the Installer that the surface on which the GCL will be placed is acceptable. The Certificate of Acceptance shall be provided prior to GCL installation.

B. After the surface has been accepted by the Installer, it is the Installer's responsibility to indicate to the Construction Manager any change in surface condition that may require repair. If the Construction Manager concurs with the Installer, then the Earthwork Subcontractor shall be notified and the Construction Manager shall confirm that the surface is repaired.

C. The subgrade shall be maintained at the specified moisture content until covered by the GCL. Upon placement of panel(s), the Installer is responsible for maintaining/repairing the surface covered by the GCL unless otherwise agreed.

3.2 EXAMINATION

A. The Engineer will collect samples of GCL to be installed for conformance testing.

3.3 INSTALLATION

A. Reinforced GCL materials shall be placed on slopes steeper than 7 to 1 (H:V). Non-reinforced GCL materials may be used on slopes flatter than 7 to 1 (H:V).

B GCL Deployment: Handle GCL in a manner to ensure it is not damaged. At a minimum, comply with the following:

1. On slopes, anchor the GCL securely and deploy it down the slope in a controlled manner.

2. Weight the GCL with sandbags or equivalent in the presence of wind.

3. Cut GCL with a geotextile cutter (hook blade), scissors, or other approved device. Protect adjacent materials from potential damage due to cutting of GCL.

4. Prevent damage to underlying layers during placement of GCL.

5. During GCL deployment, do not entrap in or beneath GCL, stones, trash, or moisture that could damage GCL.

6. Visually examine entire GCL surface. Ensure no potentially harmful foreign objects such as needles are present.

7. Do not place GCL in the rain or at time of impending rain.

8. Do not place GCL in areas of ponded water.

9. Replace GCL that is hydrated before placement of overlying geomembrane.

10. In general, only deploy GCL that can be covered during that day by geomembrane or a minimum of twelve (12) inches of approved cover soil.

11. Orient the preferred GCL surface in relation to prepared soil or other geosynthetics as directed by the Representative.

12. On side slopes, run GCL to the bottom of the slope as indicated.

13. Seam areas or runs shall also be flat and clear of any large rocks, debris or ruts.

14. Contacting surfaces shall be clean and clear of dirt or native soil with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases.

15. Overlaps shall be a minimum of six (6) inches.

16. A proper seam shall cover the six (6) inch lap line and leave the nine (9) inch match line exposed.

17. The Contractor shall only work on an area that can be completed in one working day.

18. Completion shall be defined as the full installation and anchoring of the liner and placement of the overlying specified geomembrane liner.

C. Overlaps:

1. On slopes, overlap GCL to the manufacturer's match line

2. In general, no horizontal seams are allowed on side slopes. Any horizontal seams on side slopes will be overlapped so that liquid will run from the top of the higher panel to the top of the lower panel. GCL shall not be placed so that liquid from a higher panel can run underneath a lower panel.

3. Apply granular bentonite to overlapped area at a rate of 1/4 pound per linear foot.

4. At sumps, overlap GCLs at least one (1) foot.

5. At bottom of collection sumps, unroll an extra layer of GCL on top of previously installed GCL. Avoid placing seams on top of underlying seams.
6. Seams shall be augmented with granular bentonite to ensure seam integrity.
7. Granular bentonite shall be dispersed evenly from the panel edge to the lap line at a minimum rate of ¼ pound per linear foot continuously along all seams or overlap areas.

8. Accessory bentonite shall be of the same type as the material within the composite liner itself. Adhesives may be used on seams to keep panels in contact during backfill operations, if necessary.

D. Defects and Repairs:

1. Repair all flawed or damaged areas by placing a patch of the same material extending at least one (1) foot beyond the flaw or damaged area.

2. Treat seams of repaired areas as per stated in Overlaps above.
3. The edges of the patch shall be fastened to the repaired liner with construction adhesive, in addition to the bentonite-enhanced seam.

E. Interface with Other Products: Ensure the following when deploying overlying material.

1. GCL and underlying materials are not damaged.

2. Minimal slippage of GCL on underlying layers occurs.

3. No excess tensile stresses occur in GCL.

3.4 ANCHOR TRENCH SYSTEMS

A. Anchor trenches shall be excavated to the lines and grades shown on the Drawings prior to placement of the GCL.

B. To minimize desiccation of the clay, no more than the amount of trench required for the GCL to be anchored in one day shall be excavated.

C. The corners of the anchor trench where the GCL enters the trench shall be rounded to a smooth radius prior to the installation of the GCL.

D. No loose soil shall be allowed to underlie the GCL in the anchor trench.

E. The GCL shall be temporarily anchored with sand bags or other approved means until the overlying geosynthetics are placed and secured.

3.5 EQUIPMENT

A. Storage

1. Wooden pallets for above ground storage of GCL.

2. Heavy, waterproof tarpaulin for protecting unused GCL.

B. Installation

1. Equipment used for GCL deployment shall utilize a spreader bar to prevent slings from damaging edges.

2. Steel pipe shall be inserted into roll core for lifting.

3. Sand bags for securing tarpaulin.

4. 3-inch wide grips for moving GCL panels into place for each installation technician.

5. Bentonite Sealing Compound and/or Granular Bentonite for securing around penetrations and structures.

6. Equipment used for the placement of all liners above the GCL shall not exceed a ground pressure of four (4) psi.

3.6 CONFORMANCE TESTING

A. Within 30 days of award, Contractor shall submit the results of the following interface friction tests:

• Compacted Soil -	Geosynthetic Clay Liner	ASTM D 5321
• Textured HDPE -	Geosynthetic Clay Liner	ASTM D 5321
• GCL Internal Friction Angle		ASTM D 6243

END OF SECTION 02245

ATTACHMENT 16

CONSTRUCTION QUALITY ASSURANCE MANUAL FOR GEOSYNTHETIC (SECTION 7.0: LINING SYSTEM ACCEPTANCE)

Upon written recommendation by the Geosynthetic CQA Consultant, the Construction Manager shall consider accepting the geosynthetic lining system. The conditions of acceptance are described below. The Installer and Manufacturer(s) will retain all ownership and responsibility for the geosynthetics in the lining and final cover system until acceptance by Solutia. At Solutia's discretion, the geosynthetic-lining system may be accepted in sections at points of substantial completion or upon completion of all work.

The geosynthetic lining system will be accepted by Solutia when:

1. The installation of the lining and cover system or section thereof, is finished.
2. Verification of the adequacy of all seams and repairs, including associated testing, is completed.
3. All documentation of installation is completed.
4. The Geosynthetic CQA Consultant is able to recommend acceptance.

The Geosynthetic CQA Consultant shall certify that installation has proceeded in accordance with the requirement of the Plans and Specifications except as noted to the Construction Manager. This certification shall be provided in the final certification report.

ATTACHMENT 17

REVISED TABLE OF CONTENTS FOR DESIGN REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS