Permit No.	Date	DIN
94-01	**May 6, 2010**	**10526**

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May 6, 2010
Solid Waste Section
Asheville Regional Office

Phase 3 and Phase 4 Construction Plan Application

On-site Industrial Waste Landfill No. 3

Domtar Paper Company, LLC (Formerly Weyerhaeuser Company), Plymouth, North Carolina

June 2008, Revised August 2009

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June 2008

NORTH CAROLINA PROFESSIONAL SEAL 17543 ENGINEER R. KENT NILSSON 6/4/08

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Foreword

This construction plan application includes the following report in addition to accompanying engineering drawings. The following table is provided for convenience of the reviewer in correlating the sections of this submittal with exact references to the North Carolina Department of Environment and Natural Resources (NC DENR) Solid Waste Management Rules. References are cited as subsections of NC DENR 15A NCAC 13B.0504 (2), which lists the requirements for a construction plan application.

NC DENR REFERENCE	REPORT SECTION	SHEET NO.
2.a	2.2 Surface Hydrology	3 through 5
2.b	4 Engineering Design	8 through 9
2.c	4 Engineering Design	9 through 12
2.d	4.7 Erosion Control Plan	9
2.e		16 through 20
2.f		6, 7, and 15
2.g		13
2.h.i	2.1 Site Location (Appendix A)	
2.h.ii	1.4 General Information	
2.h.iii	7.4 Long-term Use	
2.h.iv	4.9 Capacity and Anticipated Life	
2.h.v	5 Operating Procedures	
2.h.vi	4.6 Earthwork Volumes and Borrow Materials	
2.h.vii	4.7 Erosion Control Plan	
2.h.viii	4.7 Erosion Control Plan	
2.h.ix	4.8 Sediment Control Plan	
2.h.x Rule .0503(2,a) Rule .0503(2,b) Rule .0503(2,c) Rule .0503(2,d,i) Rule .0503(2,d,ii) Rule .0503(2,e) Rule .0503(2,f) Rule .0503(2,g)	 5.6.3 Gas Monitoring 7.6 Public Safety 5.6.4 Stormwater Monitoring 4 Engineering Design 2.5 Design Considerations 7.6 Public Safety 4.4 Buffer Requirements 4.8 Sediment Control Plan	
2.h.xi	3 Waste Characterization Appendix B *Phase 2 – Hydrogeologic and Geotechnical Site Characterization for a Proposed Landfill* Appendix P *Construction Quality Assurance Plan* 7 Closure/Post-Closure	

Certification

The hydrogeology work for the Domtar Paper Company's On-site Industrial Waste Landfill, Plymouth North Carolina, was performed by an RMT, Inc. consulting hydrogeologist in support of RMT North Carolina, Inc.

Dan O. Madison, Jr., P.G.
Consulting Hydrogeologist
RMT, Inc.

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Acronyms

ASTM	American Society for Testing and Materials
BMP	best management practices
CD	consolidated drained
CQA	construction quality assurance
CSTRs	continuous stirred type reactors
CU	consolidated-undrained
cy	cubic yard
DEPOSITS	Modified Deposits Performance Of Sediments In Trap Structures
DOMTAR	Domtar Paper Company, LLC
EHMW	extra high molecular weight
ft^2	square feet
FTB	film-tear bond
GCL	geosynthetic clay liner
GRI	Geosynthetics Research Institute
HDPE	high density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
I.D.	inside diameter
LCRS	leachate collection and removal system
MQCP	Manufacturer's quality control plan
msl	mean sea level
MUSLE	Modified Universal Soil Loss Equation
NC DENR	North Carolina Department of Environment and Natural Resources
NCAC	North Carolina Administrative Code
NCE&SCP&DM	North Carolina Erosion and Sediment Control Planning and Design Manual
NDG	Nuclear density-moisture gauge
NPDES	National Pollutant Discharge Elimination System
pcf	pounds per cubic foot
psf	pounds per square foot
PVC	polyvinyl chloride

QA	quality assurance
QC	quality control
RMT	RMT North Carolina, Inc.
RPR	resident project representative
SDR	Standard Dimension Ratio
SLOSS	soil loss
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
VFPE	very flexible polyethylene
VOC	volatile organic compound
Weyerhaeuser	Weyerhaeuser Company

Section 1
Introduction

1.1 Background

The Domtar Paper Company, LLC (Domtar [formerly the Weyerhaeuser Company]) facility in Plymouth, North Carolina, consists of an integrated kraft process pulp and paper mill. Solid wastes generated by facility operations are disposed of in a state-permitted, on-site landfill (Landfill No. 3). In 1998, Weyerhaeuser retained RMT North Carolina, Inc. (RMT) to design a new landfill (Landfill No. 3) that would occupy about 96 acres of a 300-acre tract of land that had been approved for use as a landfill by North Carolina Department of Environment and Natural Resources (NC DENR). Landfill No. 3 is located to the east, southeast, and south of Landfill No. 2. On May 16, 2000, NC DENR issued a Permit-To-Construct, No. 94-01, for Phase 1A of Landfill No. 3. In December 2000, NC DENR granted approval to operate Phase 1A of Landfill No. 3. In December 2000, NC DENR granted approval to operate Phase 1B and 2 of Landfill No. 3. In December 2000, NC DENR granted approval to operate Phase 1B and 2 of Landfill No. 3. Based on a waste generation rate of 155,000 cubic yards per year, Phase 1B and Phase 2 are expected to be near capacity by 2010. This document and accompanying drawings are being submitted to obtain a Permit-To-Construct for Phase 3 and Phase 4 of Landfill No. 3.

1.2 Purpose

The purpose of this set of documents is to present NC DENR with the information necessary to approve the construction plans, construction quality assurance (CQA) plan, groundwater monitoring plan, and erosion control plan. Supporting technical information on the geotechnical and hydrogeological characteristics of the site and on the chemical and physical properties of waste materials is included in the appendices to this application.

1.3 Document Overview

This document consists of the following components:

- Construction plan application: addresses the requirements of North Carolina Administrative Code (NCAC) T15A:13B.0504.
- CQA plan (Appendix P): defines the testing and documentation procedures necessary to ensure that the facility is built as designed.
- Groundwater monitoring plan (Subsection 5.6.1): establishes the location of wells and sampling protocol and analytical parameters to monitor groundwater quality at the site.

- Drawings that illustrate the design of the new landfill facility. Five sets of bound drawings are provided separately with this application. The following drawings are provided as part of this submittal:

Drawing List

SHEET NO.	TITLE
1	TITLE SHEET
2	DATA POINT LOCATION MAP
3	HISTORICAL HIGH WATER TABLE CONFIGURATION (APRIL 2, 1993)*
4	NOT USED
5	GEOLOGIC CROSS SECTIONS – SHEET 1
6	GEOLOGIC CROSS SECTIONS – SHEET 2
7	OVERALL SITE PLAN
8	LINER GRADING PLAN
9	LEACHATE PIPING PLAN
10	FINAL GRADING PLAN – PHASE 3 AND 4
11	FINAL GRADING PLAN - OVERALL
12	PHASE PROGRESSION PLAN
13	BORROW AREA SITE PLAN
14	LANDFILL DETAILS – SHEET 1
15	LANDFILL DETAILS – SHEET 2
16	LEACHATE COLLECTION AND REMOVAL SYSTEM DETAILS
17	ENGINEERING CROSS SECTIONS
18	MISCELLANEOUS DETAILS
19	EROSION CONTROL DETAILS

Data that support the design of the landfill and groundwater monitoring plan are included in the appendices to this document.

1.4 General Information

Facility Name:	Domtar Paper Company Plymouth Mill Landfill No. 3
Site Owner and Operator:	Domtar Paper Company
Primary Contact:	Bill Morris, Environmental Engineer
Production Facility Location:	Martin County, North Carolina
Disposal Facility Location:	Washington County, North Carolina
Acreage:	7.54 acres for Phases 3 and 4; 96 acres total
Proposed Facility Capacity:	560,000 cubic yards (cy) for Phases 3 and 4
Anticipated Facility Life:	5 years for Phases 3 and 4; 99 years facility life based on current and estimated waste generation rate of 100,000 cy/gr
Waste Types:	Pulp and papermaking process wastes, including boiler ash, grits, liquor dregs, lime mud, wood wastes, paper waste, pulp rejects, general mill trash, demolition debris, dewatered wastewater solids, and related materials.
Leachate Treatment:	Hard piped to mill's wastewater treatment system along the proposed access road.

Section 2
Site Characterization

2.1 Site Location

The spatial limits of Landfill No. 3 are described in Table 2-1 as the coordinates and elevations of the inside corners of the perimeter berm. The points are listed sequentially in a counterclockwise manner starting with the northern-most west corner (just west of the north sediment basin No. 1). The points represent the limits of waste, stated as State Plane Coordinates. Phase 3 and Phase 4 are located within this footprint.

The landfill is located entirely on property owned by Domtar. The relationship of the property line to the landfill is shown on Sheet No. 7, and the legal description of the area permitted for landfill development is included as Appendix A.

2.2 Surface Hydrology

The contours shown on Sheet No. 2 are based on a April 13, 2007 aerial topographic survey,. While landfilling operations will have since altered some of the grades within the existing active landfill phases, the topographic conditions Phase 3 and Phase 4 areas are relatively unchanged.

The natural topography surrounding the overall landfill site exhibits relief of greater than 40 feet, ranging from approximately mean sea level (msl) on the flood plain of Welch Creek to greater than 42 feet msl in the center of Landfill No. 2, northwest of the site. In the vicinity of Landfill No. 3, a topographic ridge trends north-south.

Landfill No. 3 lies within the Welch Creek drainage basin. A portion of the surface water, which originates as precipitation runoff, drains directly to Welch Creek on the west. The remainder drains toward the northeast into Little Mill Creek, which flows into Welch Creek north of the landfill site within Domtar property. On the west side of the site, Welch Creek flows northerly until it discharges into the Roanoke River.

Landfill No. 3 footprint is not located within the 100-year flood plain; neither does it encroach upon jurisdictional wetlands. The delineation of the 100-year floodplain and the jurisdictional wetlands are shown on Sheet No. 2. A copy of the United States Army Corps of Engineers' Notification of Jurisdictional Determination is provided in Appendix A.

2.3 Geology

The landfill site is located within the Atlantic Coastal Plain physiographic province. The Coastal Plain consists of an eastward-thickening series of sediments, ranging in age from Cretaceous to Recent. This province is characterized as a broad, level, east-southeastward-sloping plain that was formerly an ocean floor (Nelson, 1964). During the Pleistocene Epoch (2 to 3 million years ago), the ocean encroached upon land inundating the area to the present 270-foot contour line (Mundorff, 1946). Ocean levels receded and advanced several times during the Pleistocene, Epoch each advancement was at a lower level than the previous one. As a result, a series of terraces was formed, representing coastal deposition areas of previous ocean levels. The landfill site is located near the scarp formed between the lowest and geologically most recent terrace, the Pamlico, and the Talbot Terrace. Throughout most of the area, Recent to Pleistocene age sediments form a layer 25 to 100 feet thick that overlie older deposits (Nelson, 1964).

The Coastal Plain sediments in the region range in thickness from about 1,000 feet in western Washington County to about 10,000 feet at Cape Hatteras. The sediments rest unconformably on ancient crystalline rocks similar or equivalent to those of the Piedmont. Lithologically, the sedimentary formations include beds of limestone, sand, unconsolidated shells, marl, clay, and unconsolidated sandstone. Thin beds of indurated sandstone and siltstone occur locally but comprise no major lithologic unit. The regional dip of the strata is to the east with gradients ranging from 5 to 15 feet per mile. Throughout most of the area, sediments of Pleistocene and Recent age form a layer 25 to 100 feet thick topping the older deposits. The geologic formations in eastern North Carolina consist of undifferentiated Recent to Pleistocene age formations, the Miocene age Yorktown Formation, the Eocene age Castle Hayne Limestone, the Paleocene age Beaufort Formation, and the Cretaceous age formations (Nelson, 1964). These specific formations are described in Table 2-2.

The local geology has been assessed based primarily on data collected from nine soil borings, 16 test pits, seven observation wells, and 10 monitoring wells during previous investigations (*Groundwater Quality Assessment for the Existing Landfill*, RMT, October 1989 and the *Phase 2 Hydrogeologic and Geotechnical Site Characterization for a Proposed Landfill*, RMT, December 1990 (the latter report is presented in Appendix B)). Well, boring, and test pit locations are shown on Sheet No. 3.

During these investigations, seven shallow monitoring wells (MW-1 through MW-7) were installed around the existing landfill, and three deep monitoring wells (MW-1A, MW-6A, and MW-8), one deep observation well (OW-1) and six shallow water table observation wells (OW-2 through OW-7) were installed around the Landfill No. 3 site. Monitoring wells MW-1A, MW-6A, and MW-8, and observation well OW-1 were installed to monitor the water level in a partially confined aquifer underlying the water table aquifer, and to provide information regarding the distribution and characteristics of on-site clays. The shallow observation wells were installed to provide water table and hydraulic conductivity data regarding soil type and distribution in the shallow aquifer. Boring logs from these investigations were used to construct four geologic cross sections traversing the Landfill No. 3. Cross sections are presented on Sheet No. 6 and Sheet No. 7 and have been modified to reflect more recent topographic conditions based on the topographic map prepared in April 2007. The location of these wells and cross sections are shown on the Historical High Water Table Configuration (Sheet No. 3).

As shown on the geologic cross sections A-A′, B-B′, C-C′, and D-D′, the soils encountered during past investigations generally consisted of sands, silts, and clays. The dominant soil type logged in the shallow subsurface was silty sand, but many of the silty sand beds were interbedded with or interlaminated with clayey sands and clays. In most cases, the sand is fine-grained. Medium-grained and coarse-grained sand was occasionally found at depths greater than 10 feet.

2.4 Hydrogeology

Surficial sediments of Pleistocene to Recent age comprise the unconfined or water table aquifers of the area. The water table is usually within 2 to 7 feet of the land surface. Water from the shallow aquifer characteristically contains iron and is soft and corrosive. This aquifer is declining in importance as a source of domestic groundwater supplies in areas where artesian aquifers are available as sources of supply (Nelson, 1964).

The Miocene Age Yorktown aquifer contains all the confined water-bearing beds that lie above the Castle Hayne aquifer. The chemical quality of water from the Yorktown aquifer varies slightly with the lithology of the aquifer. Due to large amounts of calcareous material at all horizons in the aquifer, the water is commonly hard (Nelson, 1964).

The Eocene Age Castle Hayne Limestone is a productive aquifer in the region. Yields from individual wells are largely dependent on the thickness of the aquifer penetrated and borehole size. In Washington County, the chloride content of water from wells less than 300 feet in depth is within acceptable drinking water limits, but below this depth the water becomes increasingly brackish. In a North Carolina Department of Agriculture well in Washington County, the Castle Hayne was encountered at approximately 200 to 210 feet below the land surface (Nelson, 1964).

The formations of Cretaceous age in the area are not considered a potential source of water supply. Exploratory wells that have penetrated these formations indicate that they contain saline water throughout the area. The Beaufort Formation of Paleocene age may be a potential source of water supply; however, this potential has not been explored (Nelson, 1964).

Two aquifers, one shallow water table and one underlying the water table aquifer, were identified at the Landfill No. 3 site. As illustrated on the geologic cross sections, the shallow water table aquifer exists throughout the site. A clay layer, 15 to 18 feet thick, forms a lower confining unit for this aquifer throughout most of the site. The second aquifer is present below the clay layer. Where present, the clay unit acts as an upper confining unit or aquitard to the lower aquifer. The clay unit is present throughout most of the site but is discontinuous on the west side of the site along the flood plain to Welch Creek and on the far northeast side of the site. In these areas, the upper and lower aquifers are interconnected and groundwater occurs under water table conditions.

A map characterizing the water table, included as Sheet No. 3, was prepared using historic high groundwater levels measured on April 2, 1993. The water table contours have been adjusted to reflect isolated historical high levels measured in well MW-5 on May 16, 2003 and in wells MW-7 and MW-13 on December 1, 2005. The water table configuration shown on Sheet No. 3 represents the highest recorded levels measured since monitoring was initiated in 1989. It should be noted that an anomalously high water level was measured in MW-13 on May 16, 2003. This water level appears to be erroneous and was not used. Historic and current water level elevations are summarized on Table 2-3 and Table 2-4.

The shallow water table fluctuates with seasonal variations in precipitation and, as shown on the geologic cross sections, generally mimics the topography across the site. Groundwater in both aquifers flows from the south of the site toward Welch Creek on the west and Little Mill Creek on the north. Water levels in the water table aquifer range from approximately 2 feet below land surface in the vicinity of well OW-2 in the southwestern portion of the site, to approximately 16 feet below land surface in well MW-2 in the western portion of the site.

Two groups of private residences are located 1,900 to 2,400 feet south of Domtar's Landfill No. 2 and 500 feet from the proposed footprint of Landfill No. 3. Some of these homes rely on private wells for their domestic water supply. These wells are topographically upgradient of the landfill. Discussions with well owners and drillers in the area indicate that domestic water supply wells in the area are commonly 100 to 200 feet deep.

2.5 Design Considerations

The information generated by the hydrogeological and geotechnical investigations led to the identification of two main design considerations. The first is the location of the water table. As required in NCAC Title 15A Subchapter 13B, Section .0503, Subsection 2.d.i of the NCAC, the liner has been designed to maintain a 4-foot buffer zone between the bottom elevation of the solid waste and the seasonal high water table. This is demonstrated on the cross sections of the landfill shown on Sheet No. 17.

The second consideration was the amount of consolidation to be expected of the subgrade once the total height of the landfill has been achieved. A settlement analysis was performed in order to predict the settlement that would result from construction of the proposed waste facility. The analysis was based on two of the five consolidation curves, provided by Law Engineering and RMT; a southeast to northwest cross section of the proposed facility; and a generalized soil profile based on borings and wells SB-3, SB-6, SB-8, and MW-3.

For Phases 3 and 4 the maximum total settlement is estimated to be as much as 14.8 inches at the center of the landfill where waste loads are the highest (refer to Appendix C, Subgrade Settlement Calculations).

Interpretation of site geology, as described in Appendix B, *Phase 2 - Hydrogeological and Geotechnical Site Characterization for a Proposed Landfill*, indicates that the thick uniform deep clay aquitard laterally terminates abruptly as an erosional unconformity (resembling a scarp), rather than as a depositional pinchout. Based on our understanding of the site geology, the slope of the scarp is expected to range between 2 horizontal to 1 vertical and 4 horizontal to 1 vertical. Therefore, parameters selected for a worst-case subsurface geological model included an assumed conservative slope of 1.5 horizontal to 1 vertical for the clay scarp; a maximum thickness of 15 feet for this particular clay stratum; and a maximum differential settlement at 19 inches. Differential settlement occurring in this worst-case subsurface geology model could strain the liner by about 7 percent. Although this is probably much greater strain than the liner would actually experience, the liner design described in Section 4 could withstand this amount of strain and not rupture if subjected to the differential settlement modeled.

The leachate collection lines have been sloped to anticipate the long-term consolidation. The lines in Phases 1 through 10 have been designed with a camber with a change in grade occurring beneath the maximum height of the landfill (the location of the break line). Refer to Sheet No. 8 for the top of liner grades and the location of the break line. The lines in Phase 11 through Phase 18 compensate for the consolidation by having an initial slope of approximately 1 percent. In all cases, once the consolidation has occurred, the lines will result in a slope of no less than 0.5 percent.

Table 2-1
Site Coordinates

	NORTHING	EASTING
1	N 769689.71	E 2658387.39
2	N 769689.71	E 2658921.39
3	N 768891.14	E 2658921.39
4	N 768835.78	E 2658885.65
5	N 768510.68	E 2658822.08
6	N 768240.37	E 2658921.39
7	N 767185.78	E 2658921.39
8	N 767040.78	E 2658990.39
9	N 766823.76	E 2658990.39
10	N 766360.11	E 2658781.92
11	N 766105.12	E 2658039.18
12	N 766393.52	E 2657905.72
13	N 766198.87	E 2657258.53
14	N 767216.96	E 2656887.97
15	N 767531.20	E 2657171.61
16	N 767525.71	E 2657290.31
17	N 767594.78	E 2657392.91
18	N 767624.12	E 2657502.94
19	N 767648.04	E 2657627.08
20	N 767689.19	E 2657671.09
21	N 767842.98	E 2657705.57
22	N 767983.81	E 2657730.40
23	N 768126.81	E 2657747.66
24	N 768269.81	E 2657754.14
25	N 768414.00	E 2657935.37
26	N 768414.00	E 2658387.39

Table 2-2
Geologic Formations in Eastern North Carolina (Nelson, 1964)

SYSTEM	SERIES	FORMATION	DESCRIPTION	WATER SUPPLY
Quaternary	Recent Pleistocene	Undifferentiated	Chiefly interbedded sands and clays, with beds of shells occurring locally. Comprises a surficial layer over the entire area, ranging in thickness from 20 to 100 feet.	Present source of many domestic and farm supplies through dug and driven wells and capable of yielding small to moderate supplies throughout the area. Water is soft, relatively high in iron and locally corrosive.
Tertiary	Miocene	Yorktown Formation	Blue-gray marls, sands and shell beds interbedded with massive, dark gray, sandy clays. Extends over entire area, ranging in thickness from about 50 feet in the western part to about 300 feet in the eastern part.	Developed extensively as a source of domestic supply and is the principal aquifer in Hyde and Tyrrell Counties. Water is fairly hard but generally of good quality otherwise.
		Unnamed Formation	Brown phosphatic sand and silt with thin layers of olive-green sandy clay. Limited data on areal extent and thickness.	Has not been developed as a source of supply, but potentially a source of moderate quantities of good quality water in some areas.
	Eocene	Castle Hayne Limestone	White to light gray, porous, shell limestone, partially dolomitized at some places; white to gray calcareous sands and clays. Apparently extends throughout the area, ranging in thickness from about 120 feet to more than 400 feet.	Highly productive artesian aquifer, yielding several hundred gpm to individual wells. Principal aquifer in western Washington County. Water is hard with hydrogen sulfide common, and may be salty.
	Paleocene	Beaufort Formation	Glauconitic sands, clayey sands with beds of marl and shells occurring locally. Probably extends throughout the area, but data available limited.	Possible source of water supply in Washington County.
Cretaceous		Peedee Formation Black Creek Formation Tuscaloosa Formation	Clay, sand and sandy clay; some gravel; characteristically lenticular, often cross-bedded, drab, brown and reddish colors common.	The formations of Cretaceous age are not considered a source of potable water in the area.

Table 2-3
Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF [(2)] CASING ELEVATION	DEPTH [(1)] TO WATER 08/16/89	WATER LEVEL[(2)] ELEVATION 08/16/89	DEPTH [(1)] TO WATER 01/14/90	WATER LEVEL[(2)] ELEVATION 01/14/90	DEPTH [(1)] TO WATER 08/16/90	WATER LEVEL[(2)] ELEVATION 08/16/90	DEPTH [(1)] TO WATER 11/20/90	WATER LEVEL[(2)] ELEVATION 11/20/90	DEPTH [(1)] TO WATER 12/14/90	WATER LEVEL[(2)] ELEVATION 12/14/90	DEPTH [(1)] TO WATER 01/14/91	WATER LEVEL[(2)] ELEVATION 01/14/91	DEPTH [(1)] TO WATER 02/14/91	WATER LEVEL[(2)] ELEVATION 02/14/91
LF-01	37.59	4	33.59	NM	NM	7.91	29.68	11.42	26.17	8.88	28.71	8.17	29.42	6.21	31.38
LF-01A	37.62	NM	NM	NM	NM	NM	NM	31.54	6.08	28.5	9.12	28.42	9.2	28	9.62
LF-02	27.68	20.33	7.35	NM	NM	21.79	5.89	21.58	6.1	21.71	5.97	21.5	6.18	21.21	6.47
LF-03	10.7	5.92	4.78	NM	NM	6.12	4.58	6.12	4.58	6.21	4.49	5.92	4.78	5.96	4.74
LF-04	12.09	7.79	4.3	NM	NM	8.75	3.34	8.13	3.96	8.17	3.92	7.75	4.34	7.5	4.59
LF-05	39.16	12.17	26.99	NM	NM	13.2	25.96	13.46	25.7	13.67	25.49	13.33	25.83	13.25	25.91
LF-06	14.02	10	4.02	NM	NM	11.5	2.52	10.58	3.44	10.58	3.44	10.17	3.85	10	4.02
LF-06A	14.05	NM	NM	NM	NM	NM	NM	10.08	3.97	10.08	3.97	9.83	4.22	9.58	4.47
LF-07	36.33	6.96	29.37	NM	NM	10.83	25.5	11.17	25.16	11.17	25.16	10.75	25.58	9.75	26.58
LF-08	36.19	NM	NM	NM	NM	NM	NM	29.71	6.48	29.46	6.73	29.67	6.52	29.33	6.86
LFO-01	36.98	NM	NM	NM	NM	NM	NM	NM	NM	29.13	7.85	29.08	7.9	28.75	8.23
LFO-02	33.83	NM	NM	NM	NM	NM	NM	NM	NM	Dry	Dry	Dry	Dry	11.04	22.79
LFO-03	45.58	NM	NM	NM	NM	NM	NM	NM	NM	20.79	24.79	21.08	24.5	21.25	24.33
LFO-04	36.95	NM	NM	NM	NM	NM	NM	NM	NM	15	21.95	15	21.95	14.71	22.24
LFO-05	34.1	NM	NM	NM	NM	NM	NM	NM	NM	16.5	17.6	14.42	19.68	13.83	20.27
LFO-06	34.27	NM	NM	23.75	10.52	NM	NM	NM	NM	23.75	10.52	NM	NM	NM	NM
LFO-07	24.47	NM	NM	NM	NM	NM	NM	NM	NM	19.21	5.26	19	5.47	18.92	5.55
LFO-08	36.63	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-09	33.67	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-10	38.88	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-11	39.52	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-12	39.44	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-13	38.96	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-14	39.89	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-15	41.61	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM

(1) Measured in feet below top of casing

(2) Relative to mean sea level

Table 2-3

Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF [2] CASING ELEVATION	DEPTH [1] TO WATER 03/20/91	WATER LEVEL[2] ELEVATION 03/20/91	DEPTH [1] TO WATER 04/02/93	WATER LEVEL[2] ELEVATION 04/02/93	DEPTH [1] TO WATER 06/04/93	WATER LEVEL[2] ELEVATION 06/04/93	DEPTH [1] TO WATER 08/17/93	WATER LEVEL[2] ELEVATION 08/17/93	DEPTH [1] TO WATER 09/20/93	WATER LEVEL[2] ELEVATION 09/20/93	DEPTH [1] TO WATER 10/14/93	WATER LEVEL[2] ELEVATION 10/14/93	DEPTH [1] TO WATER 11/29/93	WATER LEVEL[2] ELEVATION 11/29/93
LF-01	37.59	5.42	32.17	2.92	34.67	6.21	31.38	8.29	29.3	8.88	28.71	9.25	28.34	9	28.59
LF-01A	37.62	27.67	9.95	23.79	13.83	25.54	12.08	27.54	10.08	28.25	9.37	28.5	9.12	28.45	9.17
LF-02	27.68	21.13	6.55	18.88	8.8	20.12	7.56	21.46	6.22	21.79	5.89	21.83	5.85	21.66	6.02
LF-03	10.7	5.83	4.87	5.78	4.92	5.79	4.91	6.29	4.41	6.33	4.37	6.38	4.32	6.17	4.53
LF-04	12.09	7.33	4.76	6.85	5.24	7.46	4.63	8.15	3.94	8.29	3.8	8.5	3.59	8.08	4.01
LF-05	39.16	14.25	24.91	10.54	28.62	11.46	27.7	12.67	26.49	13.17	25.99	13.33	25.83	13.42	25.74
LF-06	14.02	10	4.02	8.08	5.94	10.21	3.81	10.94	3.08	11	3.02	10.88	3.14	10.5	3.52
LF-06A	14.05	9.51	4.54	8.37	5.68	9.54	4.51	10.38	3.67	10.37	3.68	10.33	3.72	10	4.05
LF-07	36.33	9.92	26.41	5.92	30.41	9.38	26.95	11.58	24.75	11.75	24.58	12.12	24.21	11.96	24.37
LF-08	36.19	29.25	6.94	26.83	9.36	27.88	8.31	29.25	6.94	29.67	6.52	29.83	6.36	29.69	6.5
LFO-01	36.98	28.5	8.48	25.5	11.48	26.65	10.33	28.33	8.65	28.92	8.06	29.12	7.86	29.04	7.94
LFO-02	33.83	11.25	22.58	3.73	30.1	7.92	25.91	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
LFO-03	45.58	21.33	24.25	Dry	Dry	NM	NM	19.83	25.75	20.44	25.14	20.75	24.83	21.27	24.31
LFO-04	36.95	14.67	22.28	12.12	24.83	13.6	23.35	14.33	22.62	14.67	22.28	14.88	22.07	14.88	22.07
LFO-05	34.1	Dry	Dry	12.92	21.18	13.9	20.2	14.38	19.72	Dry	Dry	14.88	19.22	13.88	20.22
LFO-06	34.27	20.33	13.94	18.35	15.92	17.67	16.6	18.75	15.52	19.08	15.19	19.29	14.98	19.46	14.81
LFO-07	24.47	18.88	5.59	17.71	6.76	18.42	6.05	18.96	5.51	19.17	5.3	19.29	5.18	19.04	5.43
LFO-08	36.63	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-09	33.67	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-10	38.88	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-11	39.52	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-12	39.44	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-13	38.96	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-14	39.89	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-15	41.61	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM

(1) Measured in feet below top of casing

(2) Relative to mean sea level

Table 2-3

Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF [2] CASING ELEVATION	DEPTH [1] TO WATER 12/22/93	WATER LEVEL[2] ELEVATION 12/22/93	DEPTH [1] TO WATER 01/10/94	WATER LEVEL[2] ELEVATION 01/10/94	DEPTH [1] TO WATER 02/22/94	WATER LEVEL[2] ELEVATION 02/22/94	DEPTH [1] TO WATER 05/23/94	WATER LEVEL[2] ELEVATION 05/23/94	DEPTH [1] TO WATER 06/21/94	WATER LEVEL[2] ELEVATION 06/21/94	DEPTH [1] TO WATER 07/27/94	WATER LEVEL[2] ELEVATION 07/27/94	DEPTH [1] TO WATER 10/20/94	WATER LEVEL[2] ELEVATION 10/20/94
LF-01	37.59	8.27	29.32	8.12	29.47	5.53	32.06	7.05	30.54	7.96	29.63	9	28.59	7.95	29.64
LF-01A	37.62	28.33	9.29	28.69	8.93	27.8	9.82	27.3	10.32	27.93	9.69	28.57	9.05	28.72	8.9
LF-02	27.68	NM	NM	22.04	5.64	21.35	6.33	21.62	6.06	22	5.68	22.49	5.19	22.39	5.29
LF-03	10.7	NM	NM	6.5	4.2	6.4	4.3	6.75	3.95	6.9	3.8	7.12	3.58	6.95	3.75
LF-04	12.09	NM	NM	8.38	3.71	8.05	4.04	8.71	3.38	8.71	3.38	8.99	3.1	8.72	3.37
LF-05	39.16	NM	NM	14.11	25.05	13.12	26.04	13.41	25.75	13.72	25.44	14.15	25.01	14.04	25.12
LF-06	14.02	NM	NM	10.63	3.39	10.6	3.42	11.22	2.8	11.5	2.52	11.85	2.17	11.14	2.88
LF-06A	14.05	NM	NM	10.25	3.8	10.08	3.97	10.55	3.5	10.9	3.15	11.27	2.78	10.69	3.36
LF-07	36.33	11.54	24.79	12.02	24.31	11.05	25.28	11.93	24.4	11.74	24.59	14.49	21.84	12.7	23.63
LF-08	36.19	29.54	6.65	30.07	6.12	29.5	6.69	29.43	6.76	29.44	6.75	30.25	5.94	29.81	6.38
LFO-01	36.98	28.94	8.04	29.38	7.6	28.8	8.18	28.45	8.53	28.45	8.53	29.41	7.57	29.55	7.43
LFO-02	33.83	Dry	Dry	Dry	Dry	13.45	20.38	14.75	19.08	Dry	Dry	Dry	Dry	Dry	Dry
LFO-03	45.58	21.27	24.31	22.25	23.33	22.37	23.21	21.75	23.83	21.34	24.24	21.71	23.87	22.5	23.08
LFO-04	36.95	9.79	27.16	15.25	21.7	14.75	22.2	14.85	22.1	15.14	21.81	14.42	22.53	15.75	21.2
LFO-05	34.1	13.6	20.5	14.01	20.09	14.05	20.05	14.8	19.3	14.72	19.38	15	19.1	14.12	19.98
LFO-06	34.27	19.44	14.83	19.81	14.46	18.83	15.44	19.12	15.15	19.5	14.77	19.93	14.34	19.55	14.72
LFO-07	24.47	19.83	4.64	19.38	5.09	19.2	5.27	19.3	5.17	19.58	4.89	19.87	4.6	19.69	4.78
LFO-08	36.63	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-09	33.67	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-10	38.88	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-11	39.52	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-12	39.44	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-13	38.96	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-14	39.89	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-15	41.61	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM

(1) Measured in feet below top of casing

(2) Relative to mean sea level

Table 2-3
Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF (2) CASING ELEVATION	DEPTH (1) TO WATER 02/28/95	WATER LEVEL(2) ELEVATION 02/28/95	DEPTH (1) TO WATER 01/26/96	WATER LEVEL(2) ELEVATION 01/26/96	DEPTH (1) TO WATER 10/07/96	WATER LEVEL(2) ELEVATION 10/07/96	DEPTH (1) TO WATER 11/05/96	WATER LEVEL(2) ELEVATION 11/05/96	DEPTH (1) TO WATER 12/04/96	WATER LEVEL(2) ELEVATION 12/04/96	DEPTH (1) TO WATER 01/08/97	WATER LEVEL(2) ELEVATION 01/08/97	DEPTH (1) TO WATER 02/05/97	WATER LEVEL(2) ELEVATION 02/05/97
LF-01	37.59	4.92	32.67	7.05	30.54	5.9	31.69	4.65	32.94	5.96	31.63	4.25	33.34	4.38	33.21
LF-01A	37.62	27.26	10.36	28.1	9.52	26.55	11.07	26.06	11.56	26.47	11.15	26.13	11.49	25.9	11.72
LF-02	27.68	21.08	6.6	21.84	5.84	20.94	6.74	20.73	6.95	21	6.68	19.69	7.99	20.61	7.07
LF-03	10.7	6.32	4.38	NM	NM	6.2	4.5	6.12	4.58	6.22	4.48	6.04	4.66	6.02	4.68
LF-04	12.09	7.96	4.13	8.24	3.85	7.79	4.3	7.85	4.24	7.85	4.24	7.73	4.36	7.74	4.35
LF-05	39.16	13.44	25.72	13.75	25.41	12.85	26.31	12.65	26.51	12.58	26.58	12.25	26.91	12.28	26.88
LF-06	14.02	10.33	3.69	10.67	3.35	10.32	3.7	10.32	3.7	10.53	3.49	10.3	3.72	10.38	3.64
LF-06A	14.05	9.78	4.27	10.29	3.76	9.8	4.25	9.73	4.32	9.94	4.11	9.71	4.34	9.72	4.33
LF-07	36.33	11.05	25.28	12.37	23.96	10.91	25.42	10	26.33	10.03	26.3	9.3	27.03	9.03	27.3
LF-08	36.19	28.82	7.37	29.66	6.53	28.55	7.64	28.29	7.9	28.5	7.69	28.26	7.93	28.07	8.12
LFO-01	36.98	28.63	8.35	29.08	7.9	28.92	8.06	27.51	9.47	27.82	9.16	27.52	9.46	27.3	9.68
LFO-02	33.83	12.23	21.6	13.92	19.91	14.3	19.53	NM	NM	12.77	21.06	11.52	22.31	11.08	22.75
LFO-03	45.58	22.74	22.84	20.62	24.96	21.38	24.2	NM	NM	20.56	25.02	20.72	24.86	20.39	25.19
LFO-04	36.95	15.12	21.83	16.27	20.68	NM	NM	14.87	22.08	14.97	21.98	14.74	22.21	14.63	22.32
LFO-05	34.1	13.72	20.38	14.3	19.8	14.35	19.75	14.29	19.81	14.58	19.52	14.26	19.84	14.47	19.63
LFO-06	34.27	18.48	15.79	18.14	16.13	18.08	16.19	18.39	15.88	19.14	15.13	19.27	15	19.3	14.97
LFO-07	24.47	19.15	5.32	13	11.47	19.08	5.39	18.97	5.5	19.02	5.45	18.88	5.59	18.87	5.6
LFO-08	36.63	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-09	33.67	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-10	38.88	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-11	39.52	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-12	39.44	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-13	38.96	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-14	39.89	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-15	41.61	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM

(1) Measured in feet below top of casing
(2) Relative to mean sea level

Table 2-3
Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF [(2)] CASING ELEVATION	DEPTH [(1)] TO WATER 03/06/97	WATER LEVEL[(2)] ELEVATION 03/06/97	DEPTH [(1)] TO WATER 04/04/97	WATER LEVEL[(2)] ELEVATION 04/04/97	DEPTH [(1)] TO WATER 05/09/97	WATER LEVEL[(2)] ELEVATION 05/09/97	DEPTH [(1)] TO WATER 06/05/97	WATER LEVEL[(2)] ELEVATION 06/05/97	DEPTH [(1)] TO WATER 07/08/97	WATER LEVEL[(2)] ELEVATION 07/08/97	DEPTH [(1)] TO WATER 08/05/97	WATER LEVEL[(2)] ELEVATION 08/05/97	DEPTH [(1)] TO WATER 09/09/97	WATER LEVEL[(2)] ELEVATION 09/09/97
LF-01	37.59	4.31	33.28	4.71	32.88	5.21	32.38	6.54	31.05	8.1	29.49	8.28	29.31	9.07	28.52
LF-01A	37.62	25.91	11.71	25.9	11.72	26.08	11.54	26.74	10.88	27.58	10.04	27.99	9.63	28.46	9.16
LF-02	27.68	20.57	7.11	20.51	7.17	20.59	7.09	21.13	6.55	21.73	5.95	21.98	5.7	22.22	5.46
LF-03	10.7	5.96	4.74	5.99	4.71	6.03	4.67	6.34	4.36	6.71	3.99	6.76	3.94	6.92	3.78
LF-04	12.09	7.65	4.44	7.68	4.41	7.68	4.41	8.07	4.02	8.44	3.65	8.55	3.54	8.71	3.38
LF-05	39.16	12.2	26.96	12.19	26.97	12.29	26.87	12.8	26.36	13.43	25.73	13.64	25.52	13.78	25.38
LF-06	14.02	10.4	3.62	10.35	3.67	10.43	3.59	10.78	3.24	11.36	2.66	11.44	2.58	11.53	2.49
LF-06A	14.05	9.73	4.32	9.72	4.33	9.81	4.24	10.17	3.88	10.77	3.28	10.84	3.21	10.99	3.06
LF-07	36.33	8.65	27.68	5.83	30.5	9.01	27.32	9.82	26.51	10.52	25.81	11.03	25.3	11.69	24.64
LF-08	36.19	28.08	8.11	28.02	8.17	28.05	8.14	28.57	7.62	29.1	7.09	29.33	6.86	29.65	6.54
LFO-01	36.98	27.31	9.67	27.25	9.73	NM	NM	27.86	9.12	28.51	8.47	28.82	8.16	29.22	7.76
LFO-02	33.83	11.28	22.55	11.92	21.91	NM	NM	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
LFO-03	45.58	20.15	25.43	20.14	25.44	NM	NM	20.66	24.92	20.93	24.65	21.23	24.35	21.61	23.97
LFO-04	36.95	14.51	22.44	14.43	22.52	NM	NM	14.68	22.27	15.09	21.86	15.27	21.68	15.47	21.48
LFO-05	34.1	14.31	19.79	14.29	19.81	NM	NM	14.3	19.8	14.97	19.13	15.06	19.04	15.22	18.88
LFO-06	34.27	19.44	14.83	19.23	15.04	NM	NM	19.38	14.89	20.07	14.2	20.39	13.88	20.58	13.69
LFO-07	24.47	18.83	5.64	18.8	5.67	NM	NM	19.04	5.43	19.32	5.15	19.39	5.08	19.58	4.89
LFO-08	36.63	NM	NM	NM	NM	7.33	29.3	9.18	27.45	10.43	26.2	10.8	25.83	11.53	25.1
LFO-09	33.67	NM	NM	NM	NM	3.93	29.74	4.57	29.1	5.82	27.85	6.1	27.57	7.14	26.53
LFO-10	38.88	NM	NM	NM	NM	5.65	33.23	7.1	31.78	8.58	30.3	8.81	30.07	8.76	30.12
LFO-11	39.52	NM	NM	NM	NM	6.74	32.78	8.31	31.21	10.3	29.22	10.98	28.54	11.41	28.11
LFO-12	39.44	NM	NM	NM	NM	7.79	31.65	9.41	30.03	10.8	28.64	11.45	27.99	12.03	27.41
LFO-13	38.96	NM	NM	NM	NM	8.24	30.72	9.51	29.45	10.93	28.03	11.78	27.18	12.47	26.49
LFO-14	39.89	NM	NM	NM	NM	10.57	29.32	11.41	28.48	12.53	27.36	13.18	26.71	13.77	26.12
LFO-15	41.61	NM	NM	NM	NM	15.25	26.36	15.57	26.04	16.06	25.55	16.48	25.13	16.97	24.64

(1) Measured in feet below top of casing
(2) Relative to mean sea level

Table 2-3

Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF [2] CASING ELEVATION	DEPTH [1] TO WATER 10/07/97	WATER LEVEL[2] ELEVATION 10/07/97	DEPTH [1] TO WATER 11/04/97	WATER LEVEL[2] ELEVATION 11/04/97	DEPTH [1] TO WATER 12/10/98	WATER LEVEL[2] ELEVATION 12/10/98	DEPTH [1] TO WATER 04/17/98	WATER LEVEL[2] ELEVATION 04/17/98	DEPTH [1] TO WATER 09/11/98	WATER LEVEL[2] ELEVATION 09/11/98	DEPTH [1] TO WATER 10/06/98	WATER LEVEL[2] ELEVATION 10/06/98	DEPTH [1] TO WATER 11/10/98	WATER LEVEL[2] ELEVATION 11/10/98
LF-01	37.59	8.93	28.66	8.83	28.76	8.05	29.54	4.38	33.21	NM	NM	NM	NM	NM	NM
LF-01A	37.62	28.55	9.07	28.74	8.88	28.32	9.3	25.04	12.58	NM	NM	NM	NM	NM	NM
LF-02	27.68	22.08	5.6	22.08	5.6	21.8	5.88	19.89	7.79	NM	NM	NM	NM	NM	NM
LF-03	10.7	6.9	3.8	6.7	4	6.48	4.22	5.75	4.95	NM	NM	NM	NM	NM	NM
LF-04	12.09	8.57	3.52	8.42	3.67	8.2	3.89	7.41	4.68	NM	NM	NM	NM	NM	NM
LF-05	39.16	13.82	25.34	13.74	25.42	13.42	25.74	12.23	26.93	NM	NM	NM	NM	NM	NM
LF-06	14.02	11.21	2.81	11.06	2.96	7.26	6.76	9.93	4.09	NM	NM	NM	NM	NM	NM
LF-06A	14.05	10.69	3.36	10.57	3.48	10.27	3.78	9.22	4.83	NM	NM	NM	NM	NM	NM
LF-07	36.33	11.86	24.47	11.77	24.56	11.86	24.47	9.43	26.9	NM	NM	NM	NM	NM	NM
LF-08	36.19	29.62	6.57	29.62	6.57	29.37	6.82	27.5	8.69	NM	NM	NM	NM	NM	NM
LFO-01	36.98	29.25	7.73	29.36	7.62	29.04	7.94	26.58	10.4	28.55	8.43	28.95	8.03	29.18	7.8
LFO-02	33.83	Dry	Dry	Dry	Dry	Dry	Dry	NM	NM	NM	NM	NM	NM	NM	NM
LFO-03	45.58	21.87	23.71	22.06	23.52	22.26	23.32	18.91	26.67	21.4	24.18	20.47	25.11	20.98	24.6
LFO-04	36.95	15.48	21.47	15.41	21.54	5.41	31.54	14.28	22.67	14.59	22.36	14.88	22.07	14.95	22
LFO-05	34.1	14.89	19.21	14.32	19.78	14.81	19.29	14.93	19.17	14.93	19.17	16.04	18.06	16.57	17.53
LFO-06	34.27	20.48	13.79	20.49	13.78	20.38	13.89	19.98	14.29	23.2	11.07	21.27	13	21.58	12.69
LFO-07	24.47	14.47	10	19.35	5.12	19.47	5	NM	NM	NM	NM	11.57	12.9	NM	NM
LFO-08	36.63	11.6	25.03	11.35	25.28	11.05	25.58	7.62	29.01	11.42	25.21	NM	NM	NM	NM
LFO-09	33.67	4.07	29.6	6.46	27.21	6.06	27.61	3.35	30.32	7.25	26.42	7.99	25.68	NM	NM
LFO-10	38.88	8.32	30.56	8.44	30.44	7.53	31.35	4.02	34.86	8.02	30.86	9.17	29.71	NM	NM
LFO-11	39.52	11.47	28.05	11.57	27.95	11.08	28.44	4.07	35.45	11.3	28.22	11.56	27.96	NM	NM
LFO-12	39.44	12.26	27.18	12.54	26.9	12.47	26.97	5.83	33.61	11.9	27.54	12.32	27.12	NM	NM
LFO-13	38.96	12.64	26.32	12.82	26.14	12.51	26.45	6.59	32.37	12.43	26.53	12.83	26.13	NM	NM
LFO-14	39.89	13.98	25.91	14.2	25.69	14.32	25.57	9.21	30.68	13.31	26.58	13.66	26.23	NM	NM
LFO-15	41.61	17.22	24.39	17.45	24.16	NM	NM	13.43	28.18	15.63	25.98	16	25.61	NM	NM

(1) Measured in feet below top of casing

(2) Relative to mean sea level

Table 2-3
Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF [2] CASING ELEVATION	DEPTH [1] TO WATER 01/14/99	WATER LEVEL[2] ELEVATION 01/14/99	DEPTH [1] TO WATER 02/03/99	WATER LEVEL[2] ELEVATION 02/03/99	DEPTH [1] TO WATER 02/26/99	WATER LEVEL[2] ELEVATION 02/26/99	DEPTH [1] TO WATER 03/29/99	WATER LEVEL[2] ELEVATION 03/29/99	DEPTH [1] TO WATER 04/26/99	WATER LEVEL[2] ELEVATION 04/26/99	DEPTH [1] TO WATER 05/18/99	WATER LEVEL[2] ELEVATION 05/18/99	DEPTH [1] TO WATER 06/21/99	WATER LEVEL[2] ELEVATION 06/21/99
LF-01	37.59	NM	NM	10.04	27.55	10.03	27.56	NM	NM	10.28	27.31	NM	NM	10.78	26.81
LF-01A	37.62	NM	NM	27.45	10.17	27.25	10.37	NM	NM	27.36	10.26	NM	NM	28.12	9.5
LF-02	27.68	NM	NM	21.02	6.66	21.06	6.62	NM	NM	21.32	6.36	NM	NM	21.88	5.8
LF-03	10.7	NM	NM	6.2	4.5	6.24	4.46	NM	NM	6.48	4.22	NM	NM	6.65	4.05
LF-04	12.09	NM	NM	7.89	4.2	7.98	4.11	NM	NM	8.23	3.86	NM	NM	8.54	3.55
LF-05	39.16	NM	NM	12.39	26.77	12.48	26.68	NM	NM	NM	NM	NM	NM	13.18	25.98
LF-06	14.02	NM	NM	10.3	3.72	10.45	3.57	NM	NM	10.77	3.25	NM	NM	11.1	2.92
LF-06A	14.05	NM	NM	9.73	4.32	9.87	4.18	NM	NM	10.14	3.91	NM	NM	10.53	3.52
LF-07	36.33	NM	NM	10.85	25.48	10.66	25.67	NM	NM	10.72	25.61	NM	NM	11.42	24.91
LF-08	36.19	NM	NM	28.82	7.37	28.76	7.43	NM	NM	NM	NM	NM	NM	29.43	6.76
LFO-01	36.98	28.75	8.23	NM	NM	28.28	8.7	28.26	8.72	28.35	8.63	28.55	8.43	28.96	8.02
LFO-02	33.83	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-03	45.58	21.31	24.27	NM	NM	20.87	24.71	21.06	24.52	21.11	24.47	21.23	24.35	21.55	24.03
LFO-04	36.95	14.68	22.27	NM	NM	14.35	22.6	14.35	22.6	NM	NM	14.6	22.35	14.92	22.03
LFO-05	34.1	14.39	19.71	NM	NM	14.62	19.48	14.02	20.08	NM	NM	15.91	18.19	16.09	18.01
LFO-06	34.27	19.91	14.36	NM	NM	19.97	14.3	20.13	14.14	NM	NM	21.14	13.13	21.48	12.79
LFO-07	24.47	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
LFO-08	36.63	11.58	25.05	NM	NM	10.97	25.66	10.74	25.89	10.98	25.65	11.13	25.5	11.98	24.65
LFO-09	33.67	7.68	25.99	NM	NM	7.37	26.3	7.09	26.58	7.77	25.9	7.6	26.07	8.32	25.35
LFO-10	38.88	7.51	31.37	NM	NM	6.43	32.45	6.76	32.12	7.58	31.3	7.99	30.89	9.14	29.74
LFO-11	39.52	11.54	27.98	NM	NM	10.01	29.51	9.69	29.83	10.07	29.45	10.58	28.94	11.4	28.12
LFO-12	39.44	NM	NM	NM	NM	12.28	27.16	12.22	27.22	12.25	27.19	12.43	27.01	13.03	26.41
LFO-13	38.96	13.08	25.88	NM	NM	12.41	26.55	12.41	26.55	12.54	26.42	12.85	26.11	13.26	25.7
LFO-14	39.89	14.09	25.8	NM	NM	13.45	26.44	13.4	26.49	13.4	26.49	13.63	26.26	14.18	25.71
LFO-15	41.61	17.02	24.59	NM	NM	16.52	25.09	16.63	24.98	16.78	24.83	16.88	24.73	17.22	24.39

[1] Measured in feet below top of casing
[2] Relative to mean sea level

Table 2-3
Water Elevation Summary - August 1989 through December 1999

STATION ID	TOP OF [2] CASING ELEVATION	DEPTH [1] TO WATER 07/03/99	WATER LEVEL[2] ELEVATION 07/03/99	DEPTH [1] TO WATER 08/30/99	WATER LEVEL[2] ELEVATION 08/30/99	DEPTH [1] TO WATER 10/21/99	WATER LEVEL[2] ELEVATION 10/21/99	DEPTH [1] TO WATER 12/21/99	WATER LEVEL[2] ELEVATION 12/21/99
LF-01	37.59	NM	NM	NM	NM	NM	NM	9.37	28.22
LF-01A	37.62	NM	NM	NM	NM	NM	NM	26.32	11.3
LF-02	27.68	NM	NM	NM	NM	NM	NM	20.64	7.04
LF-03	10.7	NM	NM	NM	NM	NM	NM	6.02	4.68
LF-04	12.09	NM	NM	NM	NM	NM	NM	7.88	4.21
LF-05	39.16	NM	NM	NM	NM	NM	NM	11.94	27.22
LF-06	14.02	NM	NM	NM	NM	NM	NM	10.32	3.7
LF-06A	14.05	NM	NM	NM	NM	NM	NM	9.67	4.38
LF-07	36.33	NM	NM	NM	NM	NM	NM	8.22	28.11
LF-08	36.19	NM	NM	NM	NM	NM	NM	28.22	7.97
LFO-01	36.98	29.5	7.48	29.6	7.38	26.33	10.65	27.53	9.45
LFO-02	33.83	NM	NM	NM	NM	NM	NM	NM	NM
LFO-03	45.58	21.81	23.77	22.07	23.51	17.88	27.7	17.83	27.75
LFO-04	36.95	15.17	21.78	15.27	21.68	13.1	23.85	14.04	22.91
LFO-05	34.1	16.73	17.37	16.7	17.4	13.16	20.94	15.06	19.04
LFO-06	34.27	21.78	12.49	21.87	12.4	18.05	16.22	21.05	13.22
LFO-07	24.47	NM	NM	NM	NM	NM	NM	NM	NM
LFO-08	36.63	12.61	24.02	12.81	23.82	4.4	32.23	7.38	29.25
LFO-09	33.67	8.76	24.91	8.85	24.82	2.8	30.87	5.37	28.3
LFO-10	38.88	9.99	28.89	9.25	29.63	2.11	36.77	6.24	32.64
LFO-11	39.52	11.09	28.43	12.35	27.17	2.18	37.34	5.72	33.8
LFO-12	39.44	14.11	25.33	13.68	25.76	3.01	36.43	7.34	32.1
LFO-13	38.96	14.34	24.62	14.18	24.78	3.22	35.74	8.02	30.94
LFO-14	39.89	14.63	25.26	14.9	24.99	7.58	32.31	9.47	30.42
LFO-15	41.61	17.52	24.09	17.76	23.85	11.39	30.22	12.54	29.07

[1] Measured in feet below top of casing
[2] Relative to mean sea level

Table 2-4

Water Elevation Summary - December 1999 through February 2009

WELL NAME	12/21/99	02/24/00	05/26/00	08/15/00	11/16/00	02/27/01	06/05/01	09/12/01	12/27/01	03/26/02	06/30/02	10/30/02	05/16/03	12/30/03	12/30/04
LF-01	28.22	28.82	28.31	27.66	28.26	28.15	27.55	27.8	27.13	28.44	27.53	27.43	28.73	30.18	29.21
LF-01A	11.3	11.67	11.12	10.92	10.92	10.2	9.58	9.39	8.34	9.53	9.14	8.52	12.5	13.36	10.91
LF-02	7.04	7.31	6.97	6.99	6.75	6.43	5.99	5.82	5.23	6.09	5.59	5.18	8.49	8.38	6.76
LF-03	4.68	4.8	4.56	4.62	4.53	4.49	4.07	3.94	3.77	4.43	3.72	3.79	4.87	5.19	4.66
LF-04	4.21	4.42	4.07	4.28	4.05	3.99	3.57	3.51	3.11	3.94	3.86	3.41	4.69	5.04	4.36
LF-05	27.22	27.17	26.91	22.02	26.89	NA	NA	NA	25.2	25.13	25.31	24.57	28.71	26.1	25.1
LF-06	3.7	3.88	3.67	4.06	3.47	3.51	3.17	3.02	2.88	-0.24	2.79	3.25	4	4.54	3.79
LF-06A	4.38	4.56	4.28	4.55	4.12	4.11	3.69	3.46	3.33	3.95	2.25	2.94	4.58	5.17	4.28
LF-07	28.11	29.27	28.91	29.26	27.63	27.5	26.62	26.43	25.37	27.12	25.96	25.65	29.06	29.57	27.7
LF-08	7.97	8.25	7.85	7.93	7.74	7.37	6.86	6.69	4.79	6.86	6.39	6.13	8.49	9.13	7.75
LF-09	NA	NA	NA	NA	NA	NA	NA	NA	7.29	NA	NA	NA	9.91	10.21	9.05
LF-10	NA	NA	NA	NA	NA	NA	NA	NA	4.04	NA	NA	NA	4.92	5.26	4.91
LF-11	NA	NA	NA	NA	NA	NA	NA	NA	4.39	NA	NA	NA	5.25	5.59	5.24
LF-12	NA	NA	NA	NA	NA	NA	NA	NA	5.87	NA	NA	NA	7.14	7.58	7.27
LF-13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	24.58	19.28	17.62
LFO-04	22.91	23.2	22.79	22.86	22.36	22.02	21.75	21.64	21.14	21.19	20.91	20.9	22.19	22.12	21.45
LFO-14	25.05	27.28	26.82	27.17	24.79	23.67	22.97	22.88	21.33	22.38	22.57	21.41	26.92	28.32	23.6

WELL NAME	03/31/05	06/28/05	09/22/05	12/1/2005	03/23/06	06/06/06	08/22/06	11/27/06	02/27/07	05/30/07	08/14/07	08/07/08	11/24/08	02/23/09
LF-01	30.11	31.39	28.59	29.09	28.72	28.79	28.79	30.19	29.35	28.28	27.17	25.99	25.91	26.12
LF-01A	11.84	10.71	11.21	11.52	11.22	10.98	10.98	12.25	11.33	10.82	9.2	8.2	7.87	8.11
LF-02	5.68	6.57	6.71	7.08	6.88	6.84	6.84	7.86	7	6.58	5.48	5.03	4.68	5
LF-03	4.89	4.38	4.49	4.75	4.65	4.65	4.65	5.05	4.75	4.29	3.8	3.36	3.57	3.7
LF-04	4.74	4.09	4.29	4.51	4.29	4.28	4.28	5.06	4.46	4.04	3.29	3.02	3.22	3.31
LF-05	25.06	24.9	24.95	24.85	24.56	24.64	24.64	24.31	24.3	24.16	24.06	23.69	23.29	23.31
LF-06	4.36	3.22	3.46	3.82	3.68	3.72	3.72	4.77	3.41	3.42	2.6	2.12	2.67	2.87
LF-06A	4.83	3.75	3.94	7.56	4.23	4.18	4.18	5.23	4.48	3.8	3.05	2.58	3	3.25
LF-07	28.94	26.91	26.88	30.72	27.52	27.67	27.67	27.66	28.06	26.68	25.58	24.23	23.83	23.72
LF-08	8.29	7.65	7.79	8.04	7.92	7.4	7.4	8.54	7.54	8.11	6.49	5.27	6.13	5.74
LF-09	9.62	9.23	9.3	9.53	9.33	9.32	9.32	9.53	9.15	9.07	8.38	7.87	7.06	7.50
LF-10	5.13	4.57	4.81	4.78	4.85	4.88	4.88	5.31	5.13	4.56	4.06	3.66	3.79	4.08
LF-11	5.47	4.89	5	5.23	4.83	5.21	5.21	5.64	5.27	4.74	4.34	3.54	4.24	4.29
LF-12	7.57	6.52	6.69	7.28	7.12	6.92	6.92	7.57	7.16	6.42	5.72	4.62	5.12	5.94
LF-13	18.99	18.88	17.73	17.88	17.86	17.78	17.78	17.78	17.75	17.18	16.33	15.86	15.23	13.42
LFO-04	21.61	21.3	22.44	21.22	21.21	21.15	21.15	21.25	21.05	20.95	20.41	19.46	19.35	19.37
LFO-14	26.61	24.12	23.37	23.97	24.17	23.81	23.81	24.85	24.67	23.37	21.87	NA	NA	NA

Water level elevations are in feet MSL.

NA - Data not available

Section 3
Waste Characterization

3.1 Waste Types and Quantities

Nonhazardous solid wastes are produced by the wood products, pulp and paper-making operations processes. Other than boiler ash, most of these wastes are unique to the industry. The processes and resulting wastes are described in more detail in Section 4 of *Waste Characterization and Analysis Report*, which is included in Appendix D. Waste types include the following materials:

- **Ash**: generated by the combustion of bark, wood wastes, dewatered wastewater treatment solids, paper fiber, and plastic derived from the mill-recycled fiber facility, and coal, and other similar fuels, including fly ash from electrostatic precipitators and bottom ash off boiler grates.
- **Paper wastes**: finished paper products rendered unusable during the production process, including broke and butt ends. Most paper waste is repulped in the process, but unusable materials are disposed of from operations and offices.
- **Liquor dregs**: solids accumulated in a clarifier used to purify a solution of pulping chemicals, primarily sodium carbonate, that are generated in the recovery boiler.
- **Grits**: insoluble solids that form during the slaking process that involves the reaction of clarified liquor with lime to remove carbonate from the solution.
- **Lime mud**: fine-grained calcium carbonate recovered from the slaker in a clarifier. Lime mud from this clarifier is sent to a lime kiln for conversion to lime. Waste lime mud results when the kiln is unavailable and from clean-up and routine maintenance activities.
- **Wood waste**: bark and other waste wood materials that cannot be burned in the boilers or used in the production process due to contamination with dirt, gravel, and other materials.
- **Miscellaneous trash, demolition debris, and other trash**: inert, nonhazardous materials and minor quantities of putrescible waste collected as office waste and general refuse from the mill site.
- **Dewatered wastewater solids:** dewatered solids dredged from wastewater treatment impoundments.

Waste material to be disposed of in Phase 3 and Phase 4 will be similar to the waste that is currently being disposed of in Phase 1 and Phase 2 of Landfill No. 3.

Landfill No, 3 has historically been received dewatered sludge at a rate of approximately 65,000 cubic yards (cy) per year. After December 31, 2002, mill waste has also been received. Based on measurements of landfill volumes in Landfill No. 2 since 1996, maximum in-place disposal rates are estimated to be approximately 110,000 cy per year. Therefore, the combined waste volume for disposal for Phase 3 and Phase 4 is estimated to be as high as 175,000 cy per year. During the year 2014, the waste volume is expected to be about 153,000 cy per year. After that period (2015 onward), the disposal rate is estimated to be about 100,000 cy per year.

3.2 Chemical Testing Results

The results of a waste identification, sampling, and chemical analysis program, described in Sections 5 and 6 of *Waste Characterization and Analysis Report* (included in Appendix D), are summarized in the following paragraphs. Each of the wastes identified and tested were found to be nonhazardous by the Toxicity Characteristic Leaching Procedure (TCLP). Waste materials were also subjected to an American Society for Testing and Materials (ASTM) water leach, believed to more accurately represent actual landfill conditions, and were analyzed for metals and selected volatile organic compounds (VOCs). Overall, the test results indicate that metals and inorganic parameters such as alkalinity and total dissolved solids (TDS) would provide the most reliable indication of a release from the facility.

Results of the TCLP tests conducted in 1989 indicate that minor amounts of metals and associated inorganic species leach from the waste materials. Barium, cadmium, arsenic, chromium, and selenium were detected at concentrations ranging from 0.014 to 1.5 mg/L in the extract solutions. Three VOCs were detected in the entire suite of samples subjected to the TCLP. Methylene chloride was detected at 7 mg/L in dewatered primary wastewater solids that are currently being burned in the mill boilers. Carbon disulfide was detected at 12 mg/L in the lime waste composite (grits, dregs, and lime mud). The composite sample of paper and wood waste contained 11 mg/L of 2-butanone.

Barium, arsenic, and chromium were also detected in the water leach samples, though at lower concentrations than in the TCLP leachates. No VOCs were detected above the method detection limit in water leach samples.

Barium and cadmium were detected in the dewatered wastewater solids samples, also at lower concentrations than in the TCLP leachates. No other constituent was detected in the samples, except for the cresols, which were only detected at the quantitation limit.

3.3 Physical Testing Results

The objective of the physical testing was to derive test parameters to evaluate the ability of the wastes to be stacked in a stable manner. Since ash and dewatered 30-year-old wastewater solids dredged from wastewater treatment ponds will be major components of the waste disposed of in the facility, physical testing of these materials was conducted. A suite of tests were performed to determine the moisture content, specific gravity, unit weight, and shear strength properties of the ash and dewatered wastewater solids. Consolidation of the ash was also evaluated. These test results are summarized in the following paragraphs and are included in Appendix D. Parameters derived from these test results were used to run slope stability models of Landfill No. 3.

The specific gravity of the ash was 2.13. The average initial moisture content and dry density of the ash were approximately 40 percent and 34 pounds per cubic foot (pcf), respectively. Based on RMT's previous experience, a total unit weight value of 70 pcf is a common value for pulp and paper mill ash. Therefore, RMT selected to use the conservative value of 70 pcf instead of 51 pcf in this slope stability analysis. Direct shear tests on ash yielded a friction angle of 35 degrees and cohesion of 252 pounds per square foot (psf) for a consolidated-undrained (CU) condition. Triaxial shear strength testing under a condition produced a friction angle of 22 degrees with cohesion of 470 psf. Therefore, we used an average friction angle of 28 degrees with a conservative cohesion value of 0 psf for the CU condition slope stability analysis of ash. The same CU triaxial shear strength test with pore pressure measurements resulted in a friction angle of 41 degrees with cohesion of 0 psf. These parameters along with a typical (conservative) total unit weight for ash of 70 pcf were used in the slope stability analysis for the consolidated drained (CD) condition.

The dewatered wastewater solids testing in 1998 by Kiber Environmental Services, Inc. are more representative of the dewatered wastewater solids proposed for disposal in this landfill than those tested in 1990 and presented in RMT's 1990 report. The specific gravity of the wastewater solids tested in 1998 ranged from 1.95 to 2.34. The moisture content of the dredged wastewater solids after it was dewatered using plate and frame presses ranged from 117.8 to 169.8 percent. The dry unit weight of the dredged dewatered wastewater solids ranged from 27.1 to 31.8 pcf when compacted to a single-point reduced standard Proctor dry density. At low confining pressures (less than 7 psi), the CU triaxial shear strength cohesion ranged from 612 to 1,151 psf with friction angles that range from 19.1 to 21.5 degrees. The CD triaxial shear strength cohesion ranged from 158 to 310 psf with friction angles that ranged from 36.1 to 41.5 degrees. Since the current dewatering system consists of the Netzsch plate and frame press; shear strength parameters from the sample dewatered with Netzsch trail run No. 6 were used in the slope stability analysis. A CU cohesion of 667 psf, a CU friction angle of 21 degrees, a CD cohesion of 167 psf, a CD friction angle of 41 degrees, and average total unit weight of 70 pcf were used in the slope stability analyses for the dewatered wastewater solids. See Appendix E for additional information.

The strength parameters of the various dewatered wastewater solids and ash mixtures tested were comparable to the strength parameters for ash. The CU cohesion of the 60/40 dewatered wastewater solids/ash mixture ranged from 508 to 2,261 psf and the CU friction angles ranged from 23.6 to 35.7 degrees. Since the dewatered wastewater solids/ash combination shear strength parameters exceeded the dewatered wastewater solids only shear strength parameters, the slope stability analysis was conducted for both dewatered wastewater solids only and ash only.

These data and subsequent stability modeling (refer to Appendix E, Slope Stability Analysis) indicate that the waste mass will be stable at 3 horizontal to 1 vertical slopes. RMT performed only CU (total) and CD (effective) analysis because the wastewater solids will be dewatered prior to placement in the landfill. Consolidation testing indicates that the waste will be compressible, and only a minor amount of that moisture will be released as a result of compaction

3.4 Design and Operating Considerations

The chemical and physical test results have the following implications for the design and operation of the landfill:

- **Groundwater protection**: Metals and other inorganic complexes could potentially leach from the waste materials. In addition, consolidation of the wastes will tend to release liquids. Adequate lining and leachate collection systems are necessary. Groundwater around the facility should be monitored for these parameters listed in Subsection 5.6.1.
- **Leachate collection**: Ash and dewatered wastewater solids particles are predominantly silt sized. Leachate collection piping should be protected with adequate drainage system design features to avoid clogging.
- **Stability**: The waste materials should be stable when placed at 3:1 slopes. Wastes other than ash or adequately dewatered, compacted wastewater solids should be incorporated into the ash during operations (refer to Appendix E, Slope Stability Analysis).
- **Waste cover**: Ash and dewatered secondary waste treatment solids are soil-like materials suitable for use as a cover material.
- **Dust control**: Ash is susceptible to creating a dust hazard due to its fine-grain size and low initial moisture content. Dust control measures, such as water spreading, should be provided.

Section 4
Engineering Design

4.1 Design Variances

Domtar has requested the following design variances from NC DENR:

- **Liner configuration:** In lieu of the stipulated liner design, Domtar has proposed a composite liner system consisting of one layer of 60-mil geomembrane and one layer of geosynthetic clay liner (GCL) overlying 1 foot of compacted prepared subgrade that has a permeability of 4.2 x 10^{-4} cm/sec or less.
- **Final grade slopes:** Domtar proposes final landfill grades constructed at 3 (horizontal): 1 (vertical), with 15-foot wide intermediate drainage terraces for every 20-foot rise in elevation. Slope stability calculations, together with observations of existing Landfill No. 2 that was similarly constructed, indicate that such construction will be stable.
- **Liner base grade separation to groundwater:** Liner base grades for the entire landfill are based upon historic high groundwater levels. Base grades provide a minimum of 4 feet separation from the bottom of liner to the groundwater table, except at the leachate collection sumps. In the sump area, a 2-foot thick layer of clay will be provided in addition to the composite liner. The clay will have a maximum hydraulic conductivity of 1 x 10^{-7} cm/sec.

NC DENR has previously granted these design variances for Landfill No. 3, Phase 1A through Phase 2.

4.2 Liner System

4.2.1 Liner Design

Section .1600 of the Solid Waste Management Rules contains the requirements for design and construction of municipal solid waste landfill facilities. Rule .1624(b)(1)(A) allows for alternate liner systems, provided the owner can demonstrate compliance with the design and construction requirements of this section through appropriate site-specific modeling.

Domtar proposes the same composite liner system that has been used in Phases 1 and 2. That system includes the following elements from top to bottom (a graphic view of the proposed liner is shown on Sheet No. 14):

- 32 oz. Geocushion™ or Tenax Tendrain™ geocomposite (geonet with 12-ounce non-woven geotextile)

- 60-mil high-density polyethylene (HDPE) textured geomembrane
- GCL
- 1-foot compacted prepared subgrade with permeability of 4.2 x 10^{-4} cm/sec or less

Mass balance calculations were completed to demonstrate that based on the existing site conditions, site geology, waste characteristics, and liner performance, the proposed composite liner configuration will be protective of the 15A NCAC 2L Groundwater Standards. The results of the mass balance calculations are presented in a technical memorandum titled *Mass Balance Calculations for Liner Design of Landfill No. 3*, included in Appendix G. The calculations have been revised to reflect NC DENR comments received in a letter dated April 29, 1999 (also included in Appendix G). The calculations show that the proposed composite liner configuration will be protective of the groundwater.

4.2.2 Liner and Cap Stability

Where Landfill No. 3 will overlap Landfill No. 2, the vegetation and topsoil will be removed to expose the underlying clay cap material. Liner components for Landfill No. 3 will be placed on top of the clay and anchored on each terrace. Liner and cap stability and anchor trench design were evaluated using interface friction values for the geosynthetic components that are based on RMT's experience. These values are considered to be conservative and generally consistent. Interface friction values for the GCL/soil interface and the GCL/60-mil textured geomembrane interface, and geocomposite were based upon direct shear testing performed by Geosyntec Laboratories in Atlanta, Georgia. These are included as Figures 4-1, 4-2, and 4-3. The GCL/soil interface friction test was conducted using a lean sandy clay soil (LL = 42, PI = 17, P200 = 63). The interface friction angles shown below were used in the geotechnical analysis.

INTERFACE COMPONENT	INTERFACE FRICTION (degrees)
Stone drainage layer/Geocushion™	23
Geocushion™/textured geomembrane	36
Textured geomembrane/GCL	26
Drainage composite/textured geomembrane	36
GCL/sandy clay soil subgrade	25
Sandy soil general fill/drainage composite	34
GCL/select ash	33

Liner stability and anchor trench calculations are provided in Appendix E.

Where Landfill No. 3 overlaps Landfill No. 2, liner will be placed on relatively long slopes interrupted only by the intermediate drainage terraces. To ensure veneer stability of the leachate collection layer on top of the liner, and to limit the potential for having exposed liner for a significant period of time, the Landfill No. 3 liner on the slope face will be installed from terrace to terrace as the working face of the waste is advanced up the slope. Based on these analyses, crushed stone placed up the side slope of the terrace on the Geocushion™ following liner installation should be stable. However, the sand and select ash layer should not be placed until just prior to waste placement to avoid erosion caused by stormwater runoff.

4.3 Leachate Collection and Removal System

The leachate collection and removal system (LCRS) will be comprised of the following components:

- A drainage layer
- Perforated leachate collection lines
- Dual submersible pumps in each leachate collection sump
- A header pipe and force main

The drainage layer will consist of either an 18-inch thick graded granular filter layer or a geocomposite drainage net placed beneath a 14-inch thick graded granular filter layer. Laboratory testing has demonstrated that the latter drainage layer out performs the granular material only drainage layer. A copy of this laboratory drainage layer equivalency report is included in Appendix H. The drainage geocomposite would replace the Geocushion™ located between the HDPE liner and the aggregate. A graphic view of the proposed and alternate liner/leachate collection layers are shown on Sheet 16. The 18-inch thick graded granular filter layer would be composed of a 6-inch thick clean sand layer be placed over a 12-inch thick gravel drainage layer. The 14-inch thick graded granular filter layer would be composed of a 6-inch thick clean sand layer placed over an 8-inch thick gravel drainage layer.

The sand layer will contain less than 5 percent passing No. 200 sieve. The sand will serve to filter out fines within the waste to minimize clogging. The gravel in the lower portion of the drainage layer will be sized to provide a lateral hydraulic conductivity of at least 0.3 cm/sec. The gravel will also serve to provide bedding for the leachate collection piping and protection of the liner. The composite liner system will also be protected from damage during operations by the overlying 32-ounce Geocushion™ or geocomposite drainage layer.

The leachate collection lines will consist of 6-inch diameter perforated pipes. These pipes will be constructed of HDPE for its chemical resistivity and flexibility, and will be placed at a minimum slope of 0.5 percent. The collection pipes will have a maximum spacing of 200 feet to limit leachate head on the liner to less than 12 inches. The leachate line hydraulic calculations are provided in Appendix H. To provide protection from pipe crushing under the anticipated waste loads, the collection piping will have a maximum Standard Dimension Ratio (SDR) of 17. These calculations are presented as Appendix I, Pipe Strength Calculations. Each end of the leachate collection lines will be fitted with cleanouts to provide access for inspection or periodic cleaning.

Leachate collected by the perforated piping will flow by gravity to one or more collection sumps located in the low area of each landfill phase. Phase 3 and Phase 4 of the landfill are designed with a total of two collection sumps. Submersible pumps will pump the leachate out of the landfill. A level switch in the sump will automatically activate the dual submersible pump system, which will lift leachate into a header pipe and force main. The pumps will be installed in 18-inch diameter inclined riser pipes that are placed on the inside slope face of the lined perimeter berm. Each wheeled, submersible leachate collection pump will be attached to a cable to allow retrieval and maintenance of the pump. See Sheet No. 16 for leachate collection system details. Maintenance of the submersible pumps will be conducted in accordance with the manufacturer's recommendations.

Leachate will be pumped from the landfill through a 6-inch dual-walled leachate force main and discharged into a wet well located at the wastewater solids dewatering building on the north side of the landfill. This leachate, mixed with filtrate from the wastewater solids press building, will be recirculated onto the landfill as needed to control dust. A pump will also discharge the leachate and any filtrate from the wastewater solids dewatering activities to the mill's permitted wastewater treatment system.

Water balance modeling, including the Hydrologic Evaluation of Landfill Performance (HELP) model, was used for various landfill operational scenarios to determine leachate flow into the collection layers. The peak daily flow rate collected in the primary leachate collection layer was used to size the pumps and the force main. Tables summarizing the average and peak leachate generation rates of various phases of landfill construction are included in Appendix G.

Stormwater runon and runoff will be controlled by means of the landfill's perimeter berms and temporary stormwater control berms. The exterior berms are designed to contain, if necessary, all water falling within the landfill during a 24-hour, 25-year storm. The interior stormwater control berms (shown on Sheet No. 19) will allow segregation of stormwater and leachate so that not all precipitation falling on the landfill will have to be treated as leachate. The temporary berms will be placed to provide adequate waste disposal area, while maximizing the area where precipitation may be diverted as stormwater. The leachate pumps are sized so that even if all precipitation in the cell is treated as leachate, it may be discharged within a period of 7 days.

4.4 Buffer Requirements

As indicated in Title 15A, Subchapter 13B, Section .0503, (2)(d)(iv), this landfill must comply with the groundwater standards established under 15A NCAC 2L at the compliance boundary. The regulations also stipulate that the compliance boundary for water quality standards be set at no more than 250 feet from the waste within 50 feet of the property boundary (Title 15A, Subchapter 13B, Section .1631 (2)(A)). Based on this guidance, the waste boundary for Landfill No. 3 will be set at a total of 300 feet (where feasible) from the property boundary in order to comply with both criteria. The landfill's east boundary of Phase 3 and Phase 4 will be set a minimum of 200 feet from the property boundary in order to comply with NC DENR policy (refer to Communication Record dated January 5, 2000, included in Appendix A). The buffer zone is indicated on Sheet No. 7. The edge of waste is also located more than 500 feet from any known residence or well and more than 50 feet from any rivers or streams.

4.5 Cover System

Due to the characteristics of the wastes to be placed in the landfill, problems typical of municipal landfills, such as vectors, blowing litter, and odor generation, should not exist at the Domtar site. The waste is predominantly ash and wastewater solids. The ash is inert, and therefore poses no odor problems and is not attractive to vectors and other animals. The wastewater solids pose no odor problems; in addition, the wastewater solids are not attractive to vectors and other animals. Litter susceptible to being blown away will be covered during daily operation. Based on these points and the fact that the ash is soil-like in nature, daily cover other than ash or dewatered wastewater solids will not be utilized.

The final cover system will be constructed after the waste has reached final grades. Domtar proposes a final cover system that includes the following element from bottom to top:

- 12-inch select ash foundation layer
- GCL
- 40-mil very flexible polyethylene (VFPE) textured geomembrane liner

- Geocomposite drainage layer
- 12 inches general fill (vegetation support layer)
- 6 inches top soil

Suitable vegetation will be placed on the top layer to protect the final cover system against erosion and to enhance evapotranspiration. In order to promote surface runoff, the final cover will be sloped a minimum of 3 to 5 percent at the top and a maximum of 33 percent at the sideslopes.

A portion of the precipitation falling on the closed landfill will be lost to runoff and evapotranspiration. In Appendix G, Water and Mass Balance Calculations, it is demonstrated that this amount could be as much as 15 percent. The remainder will be intercepted by the geocomposite drainage layer and diverted to the grassed swales along the terraces. The swales will flow to articulated block drainage channels that run down the exterior face of the landfill. The flow in the drainage layer is facilitated by the low hydraulic conductivity of the underlying layer of VFPE geomembrane. Should any precipitation infiltrate beyond the VFPE geomembrane, through a poor seam or hole in the geomembrane, the GCL will act as an efficient backstop. When the GCL is hydrated, the bentonite in the mat will swell and plug the leak in the VFPE geomembrane. The purpose for the select ash leveling course is to ensure that there will be no large, hard, angular particles beneath the GCL that would tend to puncture the GCL or otherwise render it ineffective.

The components of the final cover system will act together to promote runoff and evapotranspiration and to reduce infiltration of stormwater into the waste. The final grades of the cover system are shown on Sheet No. 12. Cap detail is shown on Sheet No. 17.

4.6 Earthwork Volumes and Borrow Materials

Most of Landfill No. 3 will be constructed on fill materials above existing grades for compliance with NC DENR requirements for waste separation to groundwater and to allow for the estimated long-term subgrade settlement.

The calculated fill volumes needed for each phase are shown in Appendix J, Material Volume Calculations. Much of this fill volume is available on Domtar's property.

Weyerhaeuser (now Domtar) initiated a borrow investigation of their newly acquired properties. The purpose of this investigation was to identify sources and reserves for material suitable for general fill and select clay, for constructing Landfill No. 3, and capping Landfill No. 2 and the asbestos monofill.

Results of the borrow area investigation confirming sources and volumes of fill material suitable for general fill and select clay are included as Appendix K. RMT estimated that the upper 11 feet of both proposed borrow sites (former Snell and former Beasly properties) contain up to 250,000 cy of general fill soil and up to 515,000 cy of clayey soil.

4.7 Erosion Control Plan

In order to preserve the integrity of the final cover, a suitable stand of grass will be planted over the majority of the landfill. In addition, a terrace system has been designed to reduce the length of the drainage path of the overland runoff. When the design is implemented, terraces will be placed every 20 vertical feet on the 3 (horizontal): 1 (vertical) sideslopes. The terraces will collect sheet flow into shallow concentrated flow and will route the runoff to lined channels (refer to Sheet No. 11 and Sheet No. 18). The slope of the terraces will be a minimum of 0.5 percent. Erosion calculations were performed on these terraces using Sedimot II to predict the total sediment yield based on a 25-year, 24-hour storm event. The results showed that a total of 2,776 tons would be eroded from the north terraces, 1,959 tons would be eroded from the east terraces, and 1,963 tons would be removed from the west terraces (refer to Appendix L, Stormwater/Erosion and Sedimentation Calculations).

In addition to these permanent measures, temporary measures will be undertaken during construction to reduce erosion. These measures include silt fences at the perimeter, hay bales in the terraces before the cap is placed, and sediment traps at borrow areas.

These measures, both permanent and temporary, have been placed to reduce the amount of erosion on the landfill. In order to reduce the erosive effects of the increased runoff from the landfill, detention basins have been designed to attenuate the runoff from the finished landfill to the peak runoff rate of the existing terrain. The calculations for the design of these basins are included in Appendix L, Stormwater/Erosion and Sedimentation Calculations.

Finally, the area will be fertilized, seeded, and mulched in accordance with North Carolina Department of Transportation specifications. Completed areas will be revegetated in a timely manner so as to minimize erosion of the finished surface.

4.8 Sediment Control Plan

In order to control the amount of sediment being discharged to the surroundings in the runoff from the landfill, the detention basins described in Subsection 4.7 were also designed to reduce the amount of sediment in the discharge. The efficiency of these basins was evaluated using Sedimot II. As designed, the basins alone will remove at least 60 percent of the sediment in the influent stream. These calculations are included in Appendix L, Stormwater/Erosion and

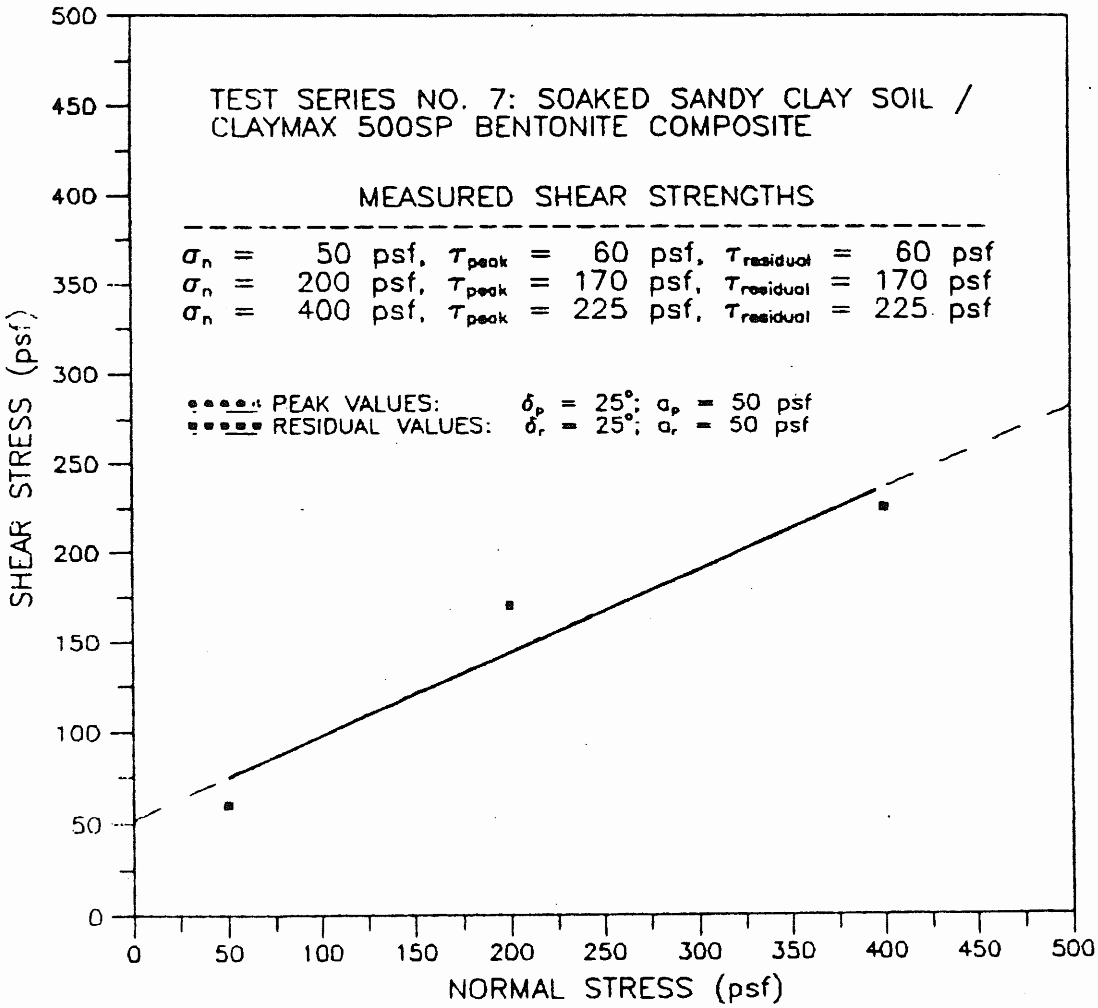
Sedimentation Calculations. Grass-lined swales along the terraces will also serve as a best management practice (BMP) to remove additional sediment.

4.9 Capacity and Anticipated Life

Landfill No. 3 will be developed and closed in 18 phases as shown on Sheet No. 13. The final closure contours are shown on Sheet No. 12. The completed facility will provide a net waste storage capacity for a site life of approximately 99 years based on current and anticipated waste generation rates (see Subsection 3.1, Waste Types and Quantities, of this document). Based on current waste generation rates, Phase 3 and Phase 4 are estimated to have a life of 5 years. Refer to Table 4-1 for a summary of the estimated life for each phase.

FIGURE 4-1

JAMES CLEM CORPORATION
INTERFACE DIRECT SHEAR TESTING



NOTE: The reported value of adhesion may not be the true adhesion of the interface, and caution should be exercised in using this adhesion value for applications involving normal stresses outside the range of stresses covered by the test.

DATE TESTED: NOVEMBER 1992

FIGURE NO.	B-13
PROJECT NO.	GL3160
DOCUMENT NO.	GEL92211
PAGE NO.	

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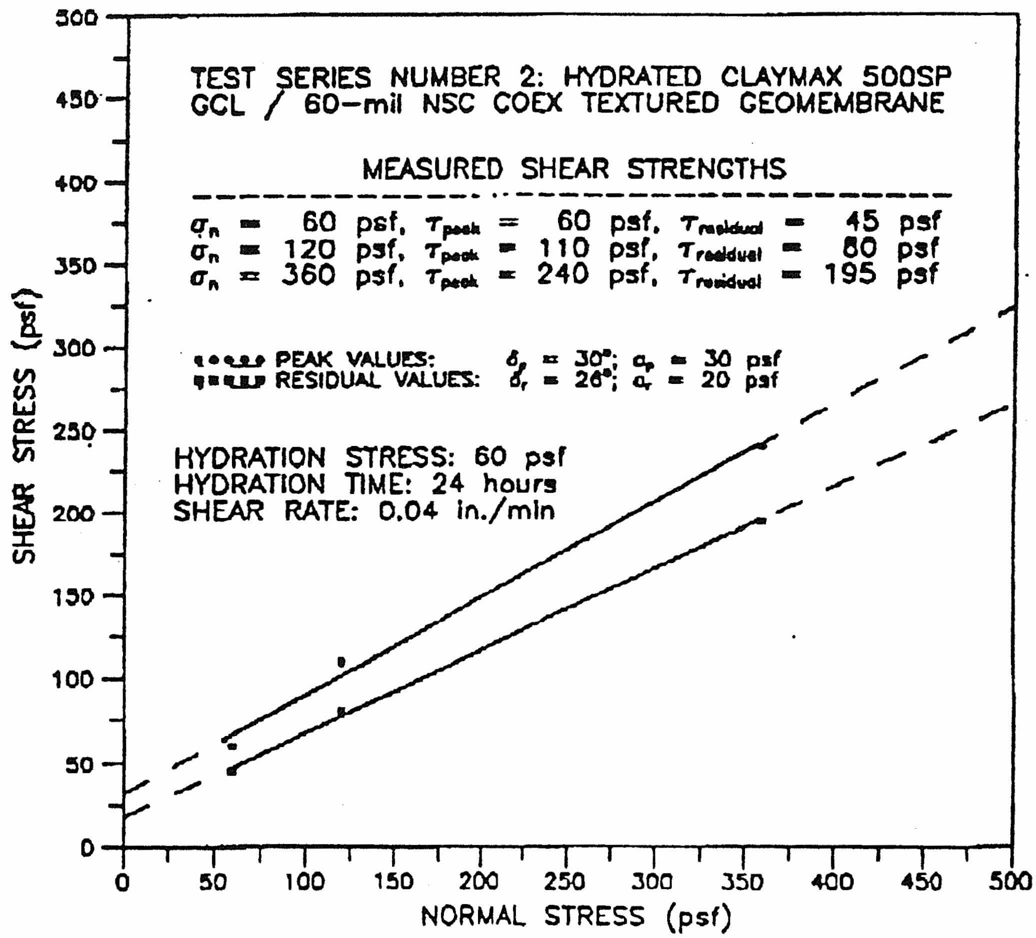
308813

FIGURE 4-2

RMT, INC.
INTERFACE DIRECT SHEAR TESTING



NOTE: The reported value of adhesion may not be the true adhesion of the interface, and caution should be exercised in using this adhesion value for applications involving normal stresses outside the range of stresses covered by the test.

DATE TESTED: 7 JULY 1993

GEOSYNTEC CONSULTANTS
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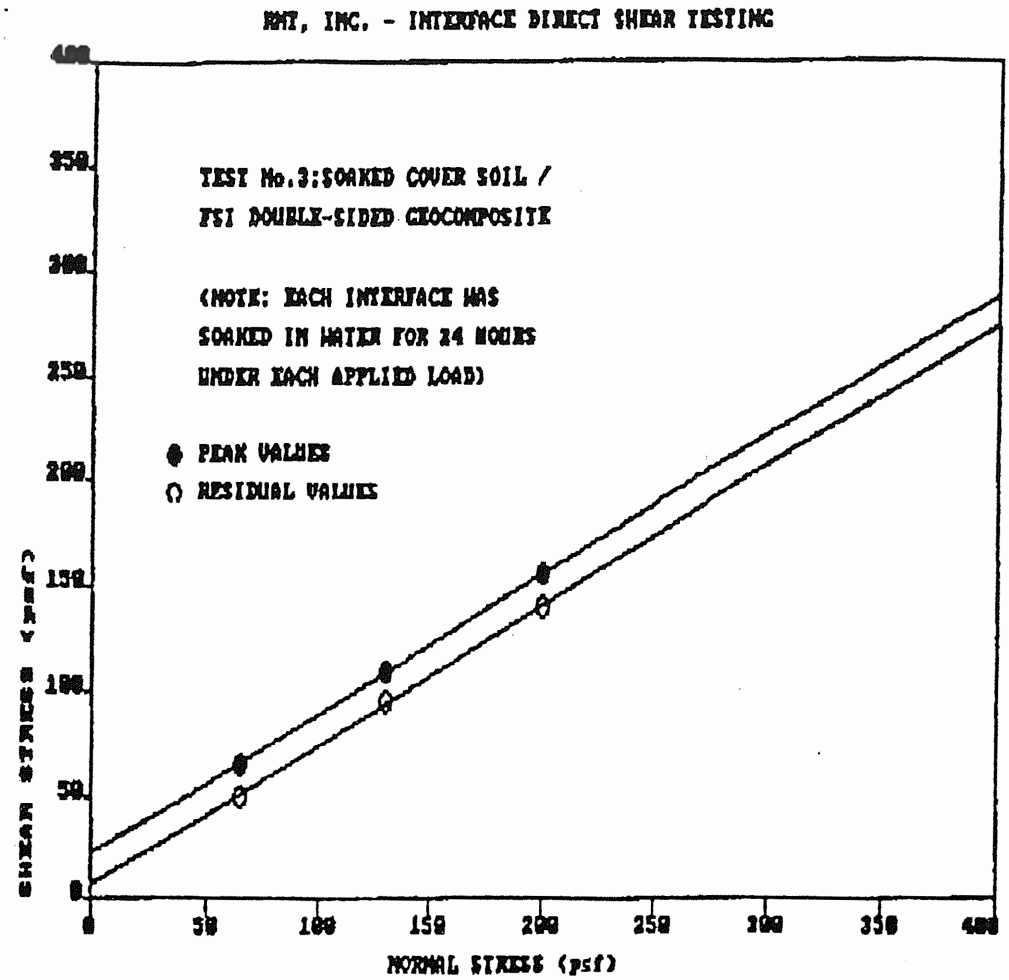
FIGURE NO.	A-4
PROJECT NO.	GL3410
DOCUMENT NO.	
PAGE NO.	

FIGURE 4-3



THE REGRESSION POLYNOMIAL OF LINE 6 - PEAK VALUES

(2.226E+01) + (6.664E-01)*X a= 20 PSF δ= 34°
THE VARIANCE - 6.170E-01

THE REGRESSION POLYNOMIAL OF LINE 7 - RESIDUAL VALUES

(7.262E+00) + (6.664E-01)*X a= 5 PSF δ= 34°
THE VARIANCE - 6.170E-01

Table 4-1
Phase Capacity [1]

PHASE	CAPACITY (cy)	ANTICIPATED LIFE [2] (years)
1A, 1B	548,103	4.4
2	682,960	3.9
3	597,000	3.4
4	864,000	7.1
5	782,000	7.8
6	810,000	8.1
7	757,000	7.6
8	773,000	7.7
9	618,000	6.2
10	499,000	5.0
11	589,000	5.9
12	368,000	3.7
13	432,000	4.3
14	458,000	4.6
15	514,000	5.1
16	562,000	5.6
17	367,000	3.7
18	528,000	5.3
Total		**99**

(1) Waste material only - excludes cap material and leachate collection layer
(2) Anticipated life of each phase was estimated by using 65,000 cy for the first two years, 175,000 cy for the next 11 years, 153,000 cy for the following year, then 100,000 cy thereafter.

Section 5
Operating Procedures

5.1 Waste Route

Waste transport vehicles will enter the facility through a new paved access road. This road is located west of the facility. Trucks will unload at the active end of the phase and exit along a temporary gravel access road on the outside of the delineation berm for the active phase. This temporary access road will allow for one-way traffic to enter on one side of the phase, unload, and exit on the opposite side of the phase. Temporary access roads will be constructed, modified, and maintained as necessary for each phase of development. A permanent haul road was constructed prior to construction of Phase 1A as shown on Sheet No. 7.

5.2 Development of Phases

Landfill No. 3 will consist of 18 phases. Phases 1 and 2 have already been constructed and are in active operation. The first nine phases will progress in a southerly direction. The final eight phases will be located to the west of the initial 10 phases. The phasing progression has been designed to allow subsequent phases to tie into the existing leachate removal system in the liner and the terrace system in the cap. Each phase subsequent to the first phase will be constructed before the preceding phase reaches capacity. Capacity development in advance of disposal need will ensure continuous waste disposal operations and aid in minimizing access conflicts between disposal operations and phase construction. The phasing progression is shown on Sheet No. 12.

5.3 Waste Handling and Placement

During initial placement of waste in a phase, special care will be taken to protect the leachate collection and removal system and the underlying liner system. The initial step for the development of a phase after the liner and leachate collection and removal systems are in place will be to ensure a minimum of 1 foot of select waste covers the lined area. This layer of select waste will be placed immediately after placement of the sand layer and just prior to placement of the waste. This select waste will consist of ash void of cinders and other large particles that could adversely impact the liner. The select waste will be unloaded from the perimeter berm into the phase to be developed. A bulldozer will then place the waste appropriately. Trucks will not be permitted on the lined area until the protection layer is in place.

After placement of the protection layer, wastes will be placed in lifts that average between 2 and 3 feet in thickness. The waste will be compacted by the successive passes of the bulldozer and the truck traffic from the hauling and dumping of the waste. As the waste grades increase with each successive lift, slopes no steeper than 3 horizontal to 1 vertical will be maintained. Maintaining the waste slopes facilitates and encourages surface drainage within the active phase. This will also ease the construction effort when the final cover is applied by minimizing the amount of regrading required. The waste mound will be built up while its leading face will advance towards the subsequent phase. This method of waste placement has been termed the "moving face" concept. Waste placement will continue to advance upward until the surface grades intersect the final waste grades.

Final grades will be achieved first in the earliest part of the phase. Prior to the placement of the final cover, a 12-inch intermediate select ash layer will be placed. Placement of the temporary covers and final cap system will occur as required to minimize leachate generation in a completed or partially completed phase.

Each subsequent phase will be constructed before the active phase reaches capacity. Construction in the subsequent phase will consist of the liner system, the leachate collection and removal system, the protection layer (select waste), and diversion berms to control stormwater runon and runoff. This will provide continuous operating capacity and compensate for construction delays due to uncontrollable circumstances such as inclement weather.

If waste characteristics change, then the operation assumptions need to be reviewed. Waste characteristics will be reviewed when the permits are reviewed, approximately every 5 years.

5.4 Abnormal Conditions

5.4.1 Inclement Weather

The operation of the landfill will continue through most weather conditions with no change in procedure. During extreme weather conditions, which require operations to cease temporarily, wastes will be stored at their source. Access to the site is by haul roads with all-weather surfaces that have the capacity to accept the traffic demands imposed by the haul trucks.

5.4.2 Equipment Breakdown

The landfill will cease operations if equipment that is essential for proper and safe operation breaks down. Operations will not continue until the equipment has been repaired or replaced and proper and safe operations can be ensured.

In the event that a haul truck breakdown occurs on the way to the landfill, the truck will be repaired or the load will be transferred to another haul truck and transported to the facility.

5.5 Leachate and Stormwater Collection and Removal

The leachate collection system for Phases 1 through 18 has been designed to flow by gravity to a series of sumps. Leachate will then be pumped to a wet well located at the wastewater solids press building. From there it will be pumped to the wastewater treatment system. In order to design the leachate collection system, the HELP model was used to determine the peak leachate generation rate. The model was based on the situation where the subsequent phase has been constructed and only a 2-foot thick (protection) layer of waste has been placed.

As discussed in Subsection 4.3, leachate will be collected in a series of sumps equipped with both primary and secondary submersible pumps. It is anticipated that during normal landfill operations, the pumps will cycle to minimize pump burnout. In the event of an extraordinary rainfall event, primary and secondary pumps will be active thereby minimizing the amount and holding time of leachate within the landfill.

The following stormwater and leachate management practices will be maintained at the landfill:

- Diversion of non-contact stormwater away from the leachate system and removal of surface water discharge outside the landfill boundary. This can be accomplished via temporary internal diversion berms within the landfill and the use of portable pumps, if necessary. Internal berms are most important in the initial time period after the landfill is opened because extreme leachate generation rates are more likely. Although the landfill system with internal stormwater diversion berms will allow for temporary storage/handling of the leachate generated from a 25-year, 24-hour storm event, it is crucial to separate and discharge non-contact stormwater before it is considered leachate. The pumps are sized to take up to 7 days to discharge leachate generated from the 25-year, 24-hour storm event.
- Limitation of the active filling area of the landfill to a small area to minimize the volume of leachate generated. This area is typically 5 acres or less depending on specific site conditions.
- Maintenance of a filling sequence that reaches final waste grades as soon as possible so that final cover soils can be placed to further divert surface water.
- Proper maintenance, operation, and monitoring of the leachate pumps, pump controls, discharge piping, leachate collection piping, and clean-outs.

A detailed operations plan is included as Appendix M.

5.6 Environmental Monitoring

NC DENR regulations stipulate that four media (*i.e.,* groundwater, leachate, gas, and stormwater) be monitored around landfill sites. The proposed monitoring plans for the site are presented in the following paragraphs.

5.6.1 Groundwater Monitoring Plan

Domtar has implemented a groundwater monitoring plan for Landfill No. 3 as required under NCAC Title 15A, Subchapter 13B, Section .0600 and in accordance with Title 15A, Subchapter 2C, Section .0100. The groundwater monitoring program was designed to provide information on groundwater quality immediately upgradient and downgradient of Landfill No. 3. These monitoring wells are located adjacent to the landfill and will detect changes in groundwater quality should a release occur. Baseline groundwater quality monitoring was performed prior to site operations to characterize existing groundwater quality. Additional baseline groundwater quality data was provided by a past investigation of Landfill No. 2 located immediately west and northwest (downgradient) of Landfill No. 3 (*Groundwater Quality Assessment for the Existing Landfill*, RMT, October 1989).

The groundwater monitoring plan consists of 13 existing monitoring wells: two wells (MW-1 and MW-1A) upgradient from the landfill, six wells (MW-2, MW-3, MW-4, MW-5, MW-6, and MW-6A) around the perimeter of Landfill No. 2, four wells (MW-9, MW-10, MW-11, and MW-12) around the perimeter of Landfill No. 3, Phase 1A, and one well (MW-13) located east of Phase 2. These monitoring well locations are shown on Sheet No. 3. The existing monitoring well nest MW-1/ MW-1A is located upgradient of all landfill activity. Well MW-1 is screened in the water table aquifer and well MW-1A is screened in the lower confined aquifer. These wells are presently used to provide background water quality data and to assess the water table configuration.

Monitoring wells MW-2 through MW-6 and MW-6A monitor groundwater quality related to Landfill No. 2 and wells MW-9 through MW-13 monitor groundwater quality related to Landfill No. 3. These wells will continue to be monitored on a semiannual basis for the parameters summarized on Table 5-1. Groundwater sampling and analysis procedures are outlined in Appendix O, Sampling and Analysis Procedures for Groundwater.

Water levels in the wells will be measured quarterly (February, May, August, and November). Data obtained from shallow wells will be used to monitor water table variations.

5.6.2 Leachate Monitoring

Leachate monitoring will not be necessary during the operating period. Leachate generated will be pumped from a sump to a wet well and then on to the wastewater treatment system. During the post-closure period, after the volume of leachate generated begins to decline, testing may be performed to determine if continued treatment is necessary. Testing guidelines shall be those established for testing the groundwater as discussed in Appendix O, Sampling and Analysis Procedures for Groundwater.

5.6.3 Gas Monitoring

Due to the predominantly inorganic nature of the wastes, it is anticipated that Landfill No. 3 will not generate appreciable amounts of gas. Therefore, a variance from gas monitoring is requested. As an added precaution, however, a passive gas collection and removal system has been included in the cap system design. The layout for this system is shown on Sheet No. 12 and details are shown on Sheet No. 18. This will be re-evaluated if the waste types or quantities vary in the future and gas generation becomes a necessary concern.

5.6.4 Stormwater Monitoring

All surface runoff from Landfill No. 3 will be directed to one of the four permanent sedimentation ponds. Stormwater discharge from these ponds will be controlled with a normally open outlet valve in the spillway outlet pipe. Discharge is either to Welch Creek or Little Mill Creek. Each pond is sized to retain the runoff from the 10-year frequency, 24-hour storm at the elevation of the principal spillway. The principal spillway has the capacity to carry a 25-year frequency, 24-hour storm event without overflowing into the emergency spillway. Water quality will be observed and recorded after each rainfall event in accordance with the mill's current National Pollutant Discharge Elimination System (NPDES) permit (General Permit No. NCG 12000, Certificate of Coverage No. NCG120012) and then released through the outlet valve.

Table 5-1
Groundwater Monitoring Parameters

PARAMETERS
Biochemical Oxygen Demand (BOD)
Chemical Oxygen Demand (COD)
Nitrate Nitrogen
Total Organic Carbon (TOC)
Chloride
Fluoride
Total Dissolved Residue
Arsenic
Barium
Cadmium
Copper
Chromium
Iron
Lead
Manganese
Mercury
Selenium
Silver
Zinc
Total Organic Halides (TOH)
Sulfate

Section 6
Construction Quality Assurance Plan

The purpose of the CQA plan is to provide procedures that will ensure that the landfill liner and final cover are constructed and documented consistent with the performance requirements discussed in Section 4, Engineering Design, of this document. The plan will also ensure that the landfill liner and cover are constructed, tested, and documented in adherence to their design and regulatory requirements. The CQA plan is included as Appendix P, CQA Plan.

Section 7
Closure/Post-closure

7.1 Closure Method

Waste will continue to be placed as discussed in Section 5, Operating Procedures, until final grades are reached. Once the surface is at the appropriate elevation, a 12-inch intermediate layer of select waste will then be placed, compacted, and graded. This layer will serve as a smooth support layer for the GCL, which is to be placed over the select waste. The GCL will be covered with a textured 40-mil VFPE geomembrane. Together, the GCL and VFPE form the barrier layer of the cover system. A geocomposite drainage layer will be placed over the textured geomembrane. The textured geomembrane will provide greater friction at the interface with the geotextile component of the geocomposite than a smooth geomembrane would. This enhanced interface friction provides additional stability to the cover system on the 3 (horizontal): 1 (vertical) sideslopes.

The final component of the cover system is the 18-inch thick vegetative layer. This layer will consist of 6 inches of topsoil and 12 inches of general fill soil capable of supporting vegetative growth. In addition, the sedimentation basins will be cleaned of sediment build-up within the basin as necessary, and this sediment, which will consist of the material eroded from the cover, will be blended into the vegetative layer.

Sheet No. 11 shows the final grades for the landfill. The sideslopes are designed to be no steeper than 3 (horizontal): 1 (vertical). The top of the final cover is sloped at 5 percent minimum with the exception of a small area at 3 percent. Detailed information regarding the landfill closure is provided in Appendix N.

7.2 Closure Schedule

To minimize leachate generation, the landfill will be progressively closed in phases as the waste reaches final grades (see Sheet No. 12). At the waste generation rate of 175,000 cy per year, Phases 3 and 4 are estimated to have a combined life expectancy of about 5 years. Domtar will begin final closure activities within 30 days of the final receipt of wastes. Final closure is not anticipated to require more than 180 days from the beginning of closure.

7.3 Post-closure Care

Domtar will regularly perform the following maintenance activities for the duration of the period of post-closure care:

- **Final Cover**: The finished cap and perimeter berm will periodically receive a walking inspection to check for and document evidence of settling, subsidence, erosion, and other potential failures of the final cover. These inspections will also encompass the perimeter berm, ditches, channels, and sedimentation basins to ensure that stormwater runon and runoff is being properly routed. These inspections, along with any repairs that were required, will be documented and kept in Domtar files.

  In addition, the landfill will be mowed, fertilized, and reseeded as needed. This will help to protect the final cover against erosion and decrease the potential for leachate generation. Any vegetation that poses a danger to the integrity of the final cover, such as trees and woody vegetation, will be discouraged and removed.

- **Pumps**: Proper maintenance of this equipment is critical to the operation of the leachate collection and transfer system. Manufacturer's recommendations for routine inspection and cleaning intervals will be followed for pumps and pump controls. In addition, all valves and flow measurement devices will be inspected and cleaned as necessary on a regular basis.

- **Piping**: The design allows for cleaning of leachate collection piping as needed. A jetting hose will be fed through cleanout openings into the leachate collection lines to scour the interior of the pipe. The jetting action will sweep sediment to the low end of the line for removal. It is anticipated that the amount of sediment removed will be minimal due to the nature of the wastes and the graded granular filter in the liner system.

- **Monitoring**: Groundwater will continue to be monitored as described in Subsection 5.6.1 for the required duration of the post-closure period.

- **Leachate Treatment**: Leachate collected in the leachate transfer station will continue to be treated in the mill wastewater treatment system for the required duration of the post-closure period unless testing establishes that leachate treatment is no longer necessary.

Detailed information regarding the landfill post-closure requirements is provided in Appendix N.

7.4 Long-term Use

Once the landfill has been closed, it will not be used for any purpose or activity that would be detrimental to the integrity of the final cover, stormwater management system, or leachate collection and removal system.

7.5 Abandonment of Leachate Collection and Environmental Monitoring Systems

The leachate collection and removal system will be abandoned when it can be shown that the leachate is no longer generated or that the leachate no longer poses a threat to human health or the environment. Abandonment of this system will consist of plugging the upstream and downstream inverts of the lines in the system, using the cleanouts and manholes for access, and removing the pumps, valves, controls, and flow measuring devices.

Abandonment of groundwater monitoring wells and piezometers will be performed in accordance with NCAC Title 15A, Subchapter 2C.

The primary method of abandonment will be removal of all well casing and screen materials. Plugging shall be accomplished by filling the entire resulting borehole with bentonite or a cement/bentonite grout from the bottom to the ground surface using a rigid tremie.

If abandonment of a well by removal is likely to be detrimental to the environment, or if attempts to abandon a well are unsuccessful, a secondary abandonment method may be used. Where all or part of a well's casing and other components cannot be removed and abandoned in accordance with the primary method, the well will be plugged by installing a cement/bentonite grout inside the well casing. The well casing and screen will be filled with a cement/bentonite grout from the bottom to the ground surface. The grout will be introduced from the bottom of the well via a rigid tremie pipe. The concrete pad will be removed and the well casing will be cut off just below the land surface.

Abandonment of these systems will be documented, including the procedure used and the date performed. This documentation will be incorporated into a report and submitted to the Solid Waste Section of the NC DENR.

7.6 Public Safety

Landfill No. 3 is located within the confines of Domtar property. This property has a perimeter fence with controlled access for authorized entry only. Therefore, public access is limited.

The wastes placed in this landfill are anticipated to have negligible potential for generating gas due to the inert nature of the waste. In addition, open burning of waste will not be allowed. Therefore, it is expected that this facility will pose no threat to the public or the environment from the generation of gas either through fires or explosions.

Section 8
References

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Appendix A
Documentation of Design Issues

Attachment A1	**Legal Description and Notification of Jurisdictional Wetlands Determination**
Attachment A2	**Communication Record dated January 5, 2000 (regarding setback from property line)**

Attachment A1
Legal Description and Notification of Jurisdictional Wetlands Determination

Attachment A2
Communication Record dated January 5, 2000
(regarding setback from property line)

Appendix B
Phase 2 – Hydrogeologic and Geotechnical Site Characterization for a Proposed Landfill

Appendix C
Subgrade Settlement Calculations

Appendix D
Waste Characterization and Analysis

Attachment D1
Waste Characterization and Analysis Report

Attachment D2
ASB Wastewater Solids TCLP Report

Attachment D3
Technical Memorandum Dated June 16, 1999, from Sharon Korleski

Evaluation of the Shear Strength of Dewatered Wastewater Solids With and Without Ash

Attachment D4
Letter Dated September 2, 1998,
From Kiber Environmental Services, Inc.

Plymouth Wastewater Solids Dewatering Project Final Data Package

Appendix E
Slope Stability Analysis

Attachment E1	**Slope Stability Findings**
Attachment E2	**SLOPE/W Computer Modeling for Ash and Wastewater Solids – 12 Runs Total**
Attachment E3	**Interface Friction Analysis**

Attachment E1
Slope Stability Findings

Slope Stability Findings

A slope stability analysis of the proposed solid waste facility was conducted using SLOPE/W software developed by GEO-SLOPE International, Ltd. Bishop's method was selected for the slope stability analysis.

This analysis was based on the following assumptions and input parameters:

- The soil borings encountered *in situ* soils that are representative of the site conditions.
- The RMT slope stability analysis evaluated two sections of the proposed landfill: a west section and an east section, both based on geological cross section C-C′ (refer to Sheet No. 7). Cross section C-C′ encompasses the general stratigraphy of the site under the most critical loading condition of the proposed landfill. The west subsurface section is based on borings MW-6, MW-6A, SB-9, OW-3, and HA-9. The east subsurface section is based on borings OW-3, HA-9, OW-1, and MW-7.
- Laboratory shear strength results are representative of site conditions. Physical properties of the proposed waste materials and the *in situ* soils used in the analyses were derived from laboratory test data by Law Engineering, Kiber Environmental Services, Inc., and RMT's past experience with similar materials.
- Since Weyerhaeuser is currently using the Netzsch method for dewatering wastewater solids, the dewatered wastewater solids shear strength parameters used in this analysis were based on the Netzsch trial run No. 6 method of dewatering.
- The groundwater table used in the analyses was based on the April 2, 1993, water table surface. It is considered the high groundwater table and it exists approximately 4 feet below the natural ground surface, based on water level readings from site monitoring and observation wells.
- The bottom of the landfill was modeled to be at least 4 feet above groundwater table surface and follows the general topography of the site. The bottom of the landfill will range in elevation from 12 to 44 feet.
- The liner will consist of a GCL, and a 60-mil HDPE-textured geomembrane, overlying 1 foot of compacted subgrade soil.
- The cap will consist of 12 inches of select ash; a GCL; a 40-mil VFPE-textured geomembrane; a geocomposite drainage layer; 12 inches of general fill (vegetation support layer); and 6 inches of topsoil.
- The perimeter dikes will consist of compacted general fill.

- The waste in the center of the landfill will be approximately 182 feet thick. The landfill's southwest side will be constructed to a maximum height of 212 feet above the existing ground surface elevation at the southwest perimeter berm. The top 10 feet of the landfill will slope away from the center of the landfill at an average slope of approximately 6 percent. The exterior side slope of the landfill will be constructed with a 3 horizontal to 1 vertical side slope that benches inward 15 feet for every 20 feet of height. RMT's analysis was conducted using a 3 horizontal to 1 vertical side slope without the terraces. This was a more conservative approach than modeling the proposed construction geometry.
- Stability was evaluated for CU conditions (short-term condition immediately following construction) and CD conditions (long-term condition sometime after construction).
- The analyses were also conducted under seismic loading conditions for the drained case. A seismic coefficient of 0.07 gravity (g) was used in the analysis. It was selected from a seismic risk map of the United States.
- A piezometric surface was modeled after the groundwater table since the leachate collection system will be designed to allow for more than 1 foot of head above the liner on the bottom of the landfill.
- Landfill waste will predominately consist of ash with some 30-year-old, dewatered wastewater solids dredged from Weyerhaeuser's wastewater treatment ponds.

The input parameters used in the analyses are as follows:

MEASUREMENT	DENSE SP/SM	MEDIUM DENSE SP/SM	LOOSE SP/SM	LOOSE SM	FIRM CL/ML/SC	SOFT CL/ML/SC	ASH	DEWATERED WASTEWATER SOLIDS
C_{CU} (psf)	0	0	0	0	350	140	0	667
ϕ_{CU} (degrees)	35	30	25	25	28	15	28	21
C'_{CD} (psf)	0	0	0	0	350	140	0	167
ϕ'_{CD} (degrees)	35	30	25	25	28	15	41	41
Total Unit Weight (pcf)	140	130	115	125	130	130	70	70

Slope Stability Findings and Conclusions

For the conditions described above, the slope stability analyses resulted in the following minimum factors of safety:

SECTION	WASTE MATERIAL	FACTORS OF SAFETY		
		CU WITHOUT PORE PRESSURE MEASUREMENTS	CU WITH PORE PRESSURE MEASUREMENTS	CU WITH PORE PRESSURE MEASUREMENTS UNDER SEISMIC LOADING CONDITIONS
East C-C'	Ash	2.01	3.08	2.31
West C-C'	Ash	2.04	3.08	2.34

SECTION	WASTE MATERIAL	FACTORS OF SAFETY		
		CU WITHOUT PORE PRESSURE MEASUREMENTS	CU WITH PORE PRESSURE MEASUREMENTS	CU WITH PORE PRESSURE MEASUREMENTS UNDER SEISMIC LOADING CONDITIONS
East C-C'	Dewatered Wastewater Solids	2.20	3.15	2.35
West C-C'	Dewatered Wastewater Solids	2.27	3.13	2.39

These results met or exceeded RMT's recommended minimum Factor of Safety of 1.50. Soil property input parameters and SLOPE/W graphical results of the slope stability analysis are attached. Graphical results and soil properties of the slope stability analysis are attached.

Based on the slope stability analysis, the construction of the proposed facility described herein is feasible. Parameters used in the Slope Stability Analysis Model are valid for the proposed facility at the proposed site for the following reasons:

- Soil parameters were obtained by testing samples from the proposed site.
- Waste parameters were obtained by testing actual samples of ash from Weyerhaeuser's existing landfill and dewatered wastewater solids dredged from Weyerhaeuser's wastewater treatment ponds. No significant change in waste material or landfill operations is expected for the new landfill.
- The highest recorded groundwater readings from the actual site were used to account for a seasonally high fluctuation in groundwater.
- The proposed geometry was based on Weyerhaeuser's needs, but limited by regulatory constraints and the seasonal high groundwater level.

However, the slope stability analysis revealed that the potential for slope failure at this site increases under the following conditions:

- A rise in the groundwater table
- Steeper slopes
- Waste materials that are placed wetter or more loosely than those in the existing landfill or those that were tested
- Actual shear strength parameters significantly less than those used in the RMT analysis
- Subgrade or subsurface soils destabilized due to poor drainage or construction equipment traffic
- Any leachate generated that is not able to adequately drain
- Soil not compacted as recommended

Design feature and operating procedure described in this application have been developed to minimize the potential for slope failures. Recommendations to construct this facility are discussed below and in Section 4.

Slope Stability Recommendations

The following recommendations are based on the subsurface exploration data obtained, the laboratory test results, and RMT's past experience with similar projects:

- Immediately prior to construction of the liner, the subgrade soils should be observed by a qualified geotechnical engineer to confirm that the subgrades are suitable for construction of the landfill.
- Placement and compaction of all controlled fill soil used to construct the landfill and sediment basins should be monitored and tested by qualified geotechnical personnel to verify that the recommended compaction has been attained.
- Careful control of the equipment traffic and drainage should be exercised throughout construction (especially during rainy weather) to prevent destabilization of the subgrade soils.
- Soil used in construction of the perimeter dikes or grading of the site should be placed in 8-inch thick (loose) lifts and compacted to at least 95 percent of the Standard Proctor (ASTM D 698) maximum dry density at ±3 percent of the optimum moisture content.
- Dewater all dredged wastewater solids by plate and frame press immediately prior to placement in landfill.
- Place and compact the waste material in lifts no more than 3 feet thick. Waste material placed in the facility should be compacted by repeated passes of the bulldozer until firm.
- Keep all waste material well drained by sloping the surface of the waste material to allow for stormwater drainage.
- In the event dewatered wastewater solids are subjected to precipitation prior to placement, blend it with ash to improve its shear strength and compaction. The shear strength of a 60/40 dewatered wastewater solids to ash blend is significantly higher than for dewatered wastewater solids alone.
- Conduct additional testing and slope stability analyses if there is a change in the waste material placed or the quality of waste material placed in the landfill.
- Waste placement operations should be such that adequate drainage of any leachate generated should be maintained at all times. RMT recommends that no more than 1 foot of head be allowed to build up within the solid waste facility.

- The side slopes should not exceed 3 horizontal to 1 vertical and the maximum height of the landfill should not exceed 212 feet. The exterior side slope should bench inward 15 feet for every 20 feet rise in height.

The findings of the slope stability analyses were based on laboratory test results from samples that are assumed to be representative. During operations, actual average properties of the ash, dewatered wastewater solids, and fill material may vary. Therefore, RMT recommends that additional laboratory testing be conducted on samples obtained during operations if significant changes are made to the waste generation processes.

Attachment E2
SLOPE/W Computer Modeling for Ash and Wastewater Solids – 12 Runs Total

Attachment E3
Interface Friction Analysis

Appendix F
Groundwater Flow Model for Liner Design

Appendix G
Water and Mass Balance Calculations

Attachment G1	**Landfill Cover and Liner Design Evaluation**
Attachment G2	**HELP Model Data**
Attachment G3	**Projected Leachate Generation Rates**
Attachment G4	**Mass Balance Calculations for Liner Design of Landfill No. 3 Technical Memorandum dated September 27, 1999 (including Responses to NC DENR letter dated April 29, 1999)**

Attachment G1
Landfill Cover and Liner Design Evaluation

Landfill Cover and Liner Design Evaluation

Introduction

The purpose of this report is to evaluate the cover and liner design in combination with site-specific climatological information to estimate the following average annual quantities:

- Precipitation
- Runoff
- Evapotranspiration
- Percolation
- Lateral drainage
- Head on the liner
- Percolation through the liner

Methods

To evaluate the design, the HELP model was used. The HELP model was developed by the United States Army Engineer Waterways Experiment Station in Vicksburg, Mississippi (Schroeder, *et al*., 1989, Volume 3), to estimate the surface runoff, subsurface drainage, and leachate from various solid waste disposal facility designs. These calculated amounts are simulated by interpreting the combined effects of precipitation, surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage, and lateral drainage.

The HELP model contains a number of inherent assumptions, which need to be considered when interpreting the calculated values for runoff, drainage, and infiltration for a landfill design. These include the following:

1. Four types of layers can be used: a vertical percolation layer, a lateral drainage layer, a barrier soil layer, and a barrier soil with a geomembrane layer.
2. The top layer may not be a geomembrane liner.
3. Lateral drainage is not permitted from a vertical percolation layer. The maximum drainage slope is 10 percent.
4. The profile can contain no more than a total of five barrier soil liners and geomembrane liners.
5. Both vertical and lateral drainage are permitted from a lateral drainage layer.

6. The top layer of the cover cannot be a barrier soil (compacted clay).
7. A barrier soil layer may not be placed adjacent to another barrier soil layer, and a geomembrane may not be placed adjacent to another geomembrane.
8. A geomembrane may not be placed directly between two barrier soil liners, and a barrier soil liner may not be placed directly between two geomembranes.
9. When a barrier soil layer or geomembrane liner is not placed directly below the lowest drainage layer, all drainage layers below the lowest liner are treated as vertical percolation layers. Thus, no lateral drainage is computed for the bottom section of the landfill.
10. Only a barrier soil or another lateral drainage layer may be placed directly below a lateral drainage layer.
11. Cover runoff is computed by using the Soil Conservation Service Runoff Curve Number method. Unless this number is manually input, the model does not consider surface slope and roughness of infiltration into the computation.
12. Percolation is modeled using Darcy's Law for saturated flow. Lateral drainage is modeled using a linearized Boussinesq equation. Evapotranspiration is modeled using a modification of the Penman method (Schroeder *et al*., 1981).

Climatologic data can be entered using one of the following three options:

- A default precipitation option
- A manual precipitation option
- A synthetic precipitation option, with a user input option

The program can generate a synthetic daily precipitation and temperature record for 1 to 20 years for any of 139 cities. The synthetic precipitation and temperature data will have approximately the same statistical characteristics as the historical data at the selected location. For this analysis, historical data for Norfolk, Virginia, were combined with 29 years (1951 to 1980) of monthly mean precipitation and temperatures for Plymouth, North Carolina, using the synthetic option with user input override to generate data. Norfolk, Virginia, is also in a coastal plain and has a climate similar to Plymouth, North Carolina.

Daily solar radiation data were also generated based on historical data from Norfolk, Virginia, and the latitude for Plymouth, North Carolina. The climatological data for Plymouth, North Carolina, is attached.

The user must enter a maximum value of leaf area index for the vegetative cover. Leaf area index is defined as the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. For this analysis, a maximum leaf area index of zero was used for the open landfill analysis and a maximum leaf area index of two was used for post-closure. Two is a typical value provided by the program for a fair stand of grass in the Norfolk, Virginia, area.

The closed facility will consist of nine distinct layers:

1. Vegetative layer
2. Geocomposite drainage layer
3. Textured 40-mil VFPE geomembrane
4. GCL
5. Waste material
6. Graded granular filter (6 inches of sand)
7. Lateral drainage layer (12 inches of crushed stone overlying a Geocushion™)
8. Textured 60-mil HDPE geomembrane
9. GCL

The open facility will consist of five distinct layers:

1. Waste material
2. Graded granular filter (6 inches of sand)
3. Lateral drainage layer (12 inches of crushed stone overlying a Geocushion™)
4. Textured 60-mil HDPE geomembrane
5. GCL

The user must also specify an evaporative zone depth. This is the maximum depth from which water may be removed from the soil by evapotranspiration. Where surface vegetation is present (post-closure conditions), the evaporative depth should at least equal the expected average depth of root penetration. Although an evaporative depth of 22 inches is recommended for a fair stand of grass in the Norfolk area, the evaporative depth was limited to 18 inches since the depth to the top of the barrier layer is 18 inches. Where surface vegetation is not present (open landfill), the evaporative depth of 8 to 18 inches is recommended for silt size soil. Therefore, an evaporative depth of 13 inches was used for the open landfill conditions.

The program allows the characteristics of each layer in the design to be entered in one of two ways. The user can choose to select default characteristic values by assigning a soil texture class number to each layer. When this method is chosen, the program provides values for each layer for porosity, wilting point, field capacity, and hydraulic conductivity. Default characteristic values were used for the various cap and liner components since no testing was performed to determine the specific values. See Table 4 from the HELP Model User's Guide for specific Default Soil, Waste, and Geosynthetic Characteristic values. The following characteristic numbers were selected to represent various components of the liner and cap.

COMPONENT	HELP DEFAULT CHARACTERISTIC #
Vegetative layer	4
Geocomposite drainage layer	20
Geomembrane	35
GCL	17
Graded granular filter (sand)	2
Lateral drainage layer (crushed stone)	21

"Soil" characteristic data for the waste was entered manually when a waste layer was considered. The porosity, hydraulic conductivity, and initial moisture content were based on RMT test data, and the wilting point and field capacity were estimated.

The geomembrane was modeled with 8 pinholes per acre of installation defects and 1 pinhole per acre of manufacturing defects per NC DENR recommendations per correspondence dated April 29, 1999 (Appendix F). The open landfill was modeled for the maximum percolation/leakage rate through the liner by not allowing for any runoff. This is a conservative assumption, since the waste material will be sloped to drain according to the recommendations of the operation plan. The open landfill was modeled with 2 feet, 4 feet, 41 feet, 81 feet, and 181 feet of waste. The cap of the closed landfill with vegetative cover over 181 feet of waste was modeled along the side and on top of the landfill.

The majority of the waste will consist of relatively dry ash. Based on Weyerhaeuser's experience with this material at their existing facility, significant pore water release is not anticipated. Therefore, it was not included in the projected leachate generation rates. Temporary stormwater controls recommended in the operating plan will also limit the quantity of leachate generated.

Conclusions

The HELP model evaluation indicates that the cover and liner design in combination with site-specific climatological data will produce the following quantities for the top and side of the landfill.

Average Annual Totals of Closed Landfill in Inches per Acre

DESCRIPTION	TOP OF LANDFILL	SIDE OF LANDFILL
Precipitation	52.35	52.35
Runoff	0.189	0.189
Evapotranspiration	7.205	7.668
Lateral drainage through the geonet	44.955	44.491
Percolation through the cover	0	0
Lateral drainage through the granular drainage layer	0	0
Percolation through the liner	0	0

The HELP model evaluation indicates that the liner design in combination with site-specific climatological data will produce the following quantities for various waste thickness.

Average Annual Totals of Open Landfill in Inches per Acre

DESCRIPTION	2' WASTE	4' WASTE	41'WASTE	81' WASTE	181' WASTE
Precipitation	52.35	52.35	52.35	52.35	52.35
Runoff	0	0	0	0	0
Evapotranspiration	31.46	31.46	31.46	31.46	31.46
Lateral drainage through the granular drainage layer	20.58	20.60	20.32	19.34	16.75
Percolation through the liner	0.00006	0.00005	0.00005	0.00004	0.00003

Attachment G2
HELP Model Data

Attachment G3
Projected Leachate Generation Rates

Attachment G4
Mass Balance Calculations for Liner Design of Landfill No. 3
Technical Memorandum dated September 27, 1999
(including Responses to NC DENR letter dated April 29, 1999)

Appendix H
Leachate Line Hydraulic Calculations and Drainage Layer Equivalency Report

Attachment H1 **Leachate Line Hydraulic Calculation**

Attachment H2 **Drainage Layer Equivalency Report**

Attachment H1
Leachate Line Hydraulic Calculation

Attachment H2
Drainage Layer Equivalency Report

Appendix I
Pipe Strength Calculations

Appendix J
Material Volume Calculations

Appendix K
Borrow Investigation

Appendix L
Stormwater/Erosion and Sedimentation Calculations

Attachment L1	**Stormwater/Erosion and Sediment Control Design**
Attachment L2	**Predevelopment Stormwater Design Calculations**
Attachment L3	**Post Development Stormwater Design Calculations – North Area**
Attachment L4	**Post Development Stormwater Design Calculations – East Area**
Attachment L5	**Post Development Stormwater Design Calculations – West Area**
Attachment L6	**Post Development Stormwater Design Calculations – North West Area**
Attachment L7	**Box Culvert Design Calculations**
Attachment L8	**Articulated Block Drainage Channel Design Calculations**
Attachment L9	**Steep Gradient Design Calculations**
Attachment L10	**Sizing of Outlet Protection**

Attachment L1
Stormwater/Erosion Control Design

Stormwater/Erosion and Sediment Control Design

Hydrograph Generation

1. The landfill was split into three areas (north, east, and west) for pre-development and post-development analyses. Two detention basins were designed for the north area (a north basin and a northwest basin). Each post-development area was further subdivided by establishing each terrace as a separate subwatershed (see attached figures).
2. Hydrographs for the existing terrain (pre-development) conditions for a 25-year, 24-hour storm were computed with a computer program that uses SCS TR-55 methodology.
3. A 25-year, 24-hour storm hydrograph was computed from each subwatershed area and routed together to obtain the peak flow rate into the detention basin and the amount of sediment erosion due to runoff using the Sedimot II modeling program.

Detention Basin Design

A post-development peak flow rate for each area was estimated for the 25-year, 24-hour storm event based on procedures outlined in the North Carolina Erosion and Sediment Control Planning and Design Manual (NCE&SCP&DM). The volume of runoff for the 10-year, 24-hour storm event was also estimated for each drainage basin. The peak flow rate, the runoff volume, the drainage basin area, and the recommendations provided in the NCE&SCP&DM were used to size the sediment pond, the principal spillway, and the emergency spillway for each drainage basin.

Flow above the riser was calculated with a program that uses culvert hydraulics to determine the flow rate from the principal spillway pipe. The program calculates the controlling flow in the detention basin due to the riser and principal spillway pipe.

1. Flow through the perforated riser was calculated using a "Discharge From Perforated Riser" Excel™ spreadsheet. The flow above the riser was added to the flow through the riser to obtain a total flow at each stage.
2. The following input is required by Sedimot II to begin the sedimentology analysis:
   - Specific gravity for sediment
   - Coefficient for distributing sediment load
   - Submerged bulk-specific gravity
   - Number of particle size distributions
   - Number of data values per particle size distribution

- Particle size distribution data (mm)
- Percent finer values corresponding to the particle size values

The specific gravity used was an average specific gravity of 2.64, which is representative of the on-site soils based on data contained in the Hydrogeologic Report (Appendix B). The eroded particle size distribution data and corresponding "percent finer" values are also representative of the on-site soils. The distribution curve used may be found in the attached calculations.

The Sedimot II user's manual recommended a coefficient of between 1.0 and 2.0 for distributing sediment load equal if the concentration varies linearly with flow rate. A coefficient of 2.00 was used.

Based on recommended values and sediment size distribution, 1.35 was chosen as the submerged bulk-specific gravity.

Sedimot II has two options available to calculate sediment yield: the Modified Universal Soil Loss Equation (MUSLE) and the Soil Loss (SLOSS). The following parameters are used in both sediment yield options for each subwatershed:

- Soil erodibility factor
- Average slope length
- Average slope in percent
- Control practice factor
- Particle size distribution

A soil erodibility factor was selected using the Soil Conservation Commission Soil Survey of Washington County, North Carolina. The site, shown on Sheet No. 4 of the soil survey, is comprised of Altavista, Conetoe, and Wickham soils. The majority of the soils at the site are Altavista and Wickham and have an erodibility factor of 0.20.

The average slope length and average slope is defined as the distance from the point of origin of overland flow until the flow enters a defined channel. The terrace face length and slope were used.

The control practice factor is defined as the ratio of sediment loss from an area with a given cover and conservation practice to that of a field in continuous fallow. A value of 0.4 for a condition of permanent seedlings from 0 to 60 days was considered to be a conservative situation and was used in this analysis.

Sedimot II gives the user the option of selecting different particle size distributions for each subwatershed. A particle size distribution from the hydrogeologic report was used. In this situation, the same distribution was utilized for all subwatershed analysis.

The MUSLE option for sediment yield was selected for each subwatershed. MUSLE calculates sediment yield, using the Williams' Modified Universal Soil Loss Equation. Eroded sediment and the combined hydrographs are routed to the "structure" (the detention basin) by travel time constants.

The outfall structure of the hydrograph was selected as a pond. The Sedimot II model predicts the performance of a user-designed sediment basin by two methods:
1) Modified Deposits Performance Of Sediments In Trap Structures (DEPOSITS); and
2) Continuous Stirred Type Reactors (CSTRs), which predicts the performance of a CSTR. The CSTRs method was selected. This method accounts for mixing between inflow concentration once flow has entered the pond. CSTRs is more reflective of sediment basin performance than the DEPOSITS prediction. The following input is required for basin analysis using CSTRs:

- Number of continuous stirred type reactors
- Time increment of routed hydrograph
- Non-ideal settling correction factor
- Percent of pool that is dead space
- Outflow withdrawal option
- Inflow vertical concentration

Sedimot II allows for up to nine CSTRs to be used, but recommends that at least two CSTRs be used. We used three CSTRs for this analysis.

Sedimot II requires that the time increment of the routed hydrograph is an integer multiple of the inflow hydrograph time increment. The default value was selected, which automatically set the value equal to the inflow time increment.

A non-ideal settling factor for a highly turbulent pond is greater than one. If natural or chemical flocculation occurs, the value is less than one. The default value of one was selected.

The percent of permanent pool that is dead storage was set at 35 percent for all three ponds.

The outflow withdrawal option is used to select the percent of water (and associated sediment) that is drawn from each of four horizontal layers of the pond. This outflow withdrawal occurs at the principal and/or emergency spillway. The options are uniform, bed, surface, and input. The uniform withdrawal system assumes that the outflow concentration is equally weighted by the concentration from each layer. A bed withdrawal system uses only the concentration from the bottommost layer to determine effluent concentration. In the surface withdrawal option, the effluent concentration is equal to the concentration of the top fall depth layer. The input option is used strictly as a research tool. The surface withdrawal option was selected.

The inflow vertical concentration option, which assumed that the inflow is completely mixed, was selected.

A stage-discharge relationship was developed so that a 10-year, 24-hour storm event could be held and then released from the detention basins. The principal spillway has the capacity to carry a 25-year, 24-hour storm event without overflowing into the emergency spillway.

The emergency spillway was designed to handle the overflow of a 100-year, 24-hour storm event. Sedimot II was run to evaluate the emergency spillway for a 100-year, 24-hour storm event. Sedimot II was also run for the 2-year, the 10-year, and the 25-year, 24-hour storm events.

Attachment L2
Predevelopment Stormwater Design Calculations

Attachment L3
Post Development Stormwater Design Calculations – North Area

Attachment L4
Post Development Stormwater Design Calculations – East Area

Attachment L5
Post Development Stormwater Design Calculations – West Area

Attachment L6
Post Development Stormwater Design Calculations – North West Area

Attachment L7
Box Culvert Design Calculations

Attachment L8
Articulated Block Drainage Channel Design Calculations

Attachment L9
Steep Gradient Design Calculations

Attachment L10
Sizing of Outlet Protection

Appendix M
Operations Plan

Phase 3 and Phase 4 - Operations Plan

On-site Industrial Waste Landfill No. 3

Domtar Paper Company, LLC (Formerly Weyerhaeuser Company), Plymouth, North Carolina

June 2008, Revised August 2009

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List of Tables

Section 1
Overview

Landfill No. 3 will be operated as an area fill. An operating area will be established on the waste surface where loads of waste will be dumped from transport and conveyor equipment. Landfill operating equipment will spread and compact waste materials into a working face that will slope downward from the operating area into the open cell bottom. The landfill operations described in the following sections will be conducted to accomplish the following objectives:

- Compact waste materials into a stable fill mass.
- Cover paper wastes that might present a blowing litter problem with soil-like waste materials such as dewatered wastewater treatment solids (fiber sludge), boiler ash, and woodyard waste (bark, grit, and reject wood chips).
- Grade all waste surfaces to promote drainage to the leachate collection drainage layer on the bottom and sides of the landfill.
- Maintain as small an operating area as possible.
- Minimize the area of operation generating leachate by using stormwater diversion berms and redirecting non-contact stormwater directly to surface drainage systems.

In addition, operations will be conducted in compliance with the provisions of NC DENR regulations Section .1626. Asbestos waste will be placed in the asbestos landfill located east of Landfill No. 2 and west of Phase 1 of Landfill No. 3.

Section 2
General Operating Requirements

Landfill operations will be conducted by a Domtar employee or a contract operator to Domtar.

Site control will be maintained at all times by a security fence and a manned guard station at the entrance to the Domtar mill. The landfill area will be accessible only to landfill operations personnel, Domtar supervisory personnel, and authorized visitors. The following activities are prohibited:

- Scavenging of waste materials
- Feeding of farm or domestic animals
- Waste fill in standing water
- Open burning

Access to the disposal area of the landfill will be established using temporary culverts and soil, ash waste or gravel as appropriate to construct ramps off the perimeter dike road into the lined fill area. Runon and runoff from waste-filled areas will be controlled at all times by the leachate collection system and the perimeter berm. Stormwater within open areas of the cell will be controlled by means of temporary stormwater diversion berms, which will allow stormwater to be discharged to the perimeter ditching rather than treated as leachate. Waste will be placed from the perimeter inward so that the side slopes may be capped as they reach final grades.

Salvage operations will not occur on a routine basis. Infrequently, the interior of the landfill might be used to store materials for recovery and use at a later date. Such materials include bark and wood waste, waste lime to be used for agricultural purposes, or dewatered fiber wastewater solids to be used as a soil amendment or other application. No hazardous wastes will be stored in the landfill. Recoverable materials will be segregated from the active waste disposal operation to the extent possible.

Daily inspections should also be performed to evaluate leachate levels within the landfill. Impermeable waste streams, such as ash, should be concentrated within the cell as much as possible to allow direct runoff into the leachate collection layer. Care should be taken to place various waste streams in appropriate locations that assist the operation of the leachate system as well as the evolution of the cell. This includes leaving some freeboard along the edge of the perimeter berms. Waste should not be placed in such a manner as to spill on to the tops of these berms. The free board will leave access to the drainage layer against the wall of the berm allowing leachate runoff access to the collection system below.

Working faces should be kept as small as possible, and areas should be capped as they are completed to the designed grades. Placing waste from the edge of the cell inward will afford the opportunity to cap sections sooner. Stormwater that flows off the capped sections will be diverted to the perimeter drainage ditches and will not be collected as leachate. These common landfill operational practices will compliment a stormwater control berm.

The design features and operating procedures described in this application have been developed to minimize the potential for slope failure. However, the slope stability analysis has revealed that the potential for slope failure at this site increases under the following conditions:

- Steeper slopes than planned
- Waste placed much looser or wetter than in the existing landfill or that which was tested.
- Soil or waste not compacted as recommended
- A rise in the groundwater table
- Leachate not able to adequately drain
- Shear strength parameters less than those used in the analysis
- Subgrade soils destabilized due to poor drainage or construction equipment traffic

To minimize the potential occurrence of these conditions, the following operational procedures are recommended:

- Have the subgrade soils observed by a qualified geotechnical engineer immediately prior to construction of the liner to confirm that the subgrades are suitable for construction of the landfill.
- Have qualified geotechnical personnel monitor placement and test compaction of all controlled fill soil used to construct the landfill and sediment basins to verify that the recommended compaction has been attained.
- Control the equipment traffic and drainage throughout construction (especially during rainy weather) to prevent destabilization of the subgrade soils.
- Place soil used in construction of the sediment basins, perimeter dikes, or grading of the site in lifts no more than 8 inches thick (loose). Compact the soil to at least 95 percent of the Standard Proctor (ASTM D 698) maximum dry density at ±3 percent of the optimum moisture content.
- Dewater all dredge wastewater solids by plate and frame press immediately prior to placement in landfill.
- Place and compact the waste material in lifts no more than 3 feet thick. Waste material placed in the facility should be compacted by repeated passes of the bulldozer until firm.

- Keep all waste material well drained by sloping the surface of the waste material to allow for stormwater drainage.
- Conduct additional testing and slope stability analyses if there is a change in the waste material placed or the quality of waste material placed in the landfill.
- Maintain adequate drainage of any leachate generated during waste placement operations. RMT recommends that no more than 1 foot of head be allowed to build up within the solid waste facility.
- Construct side slopes no steeper than 3 horizontal to 1 vertical to a height not greater than 214 feet. Bench exterior side slopes inward 15 feet for every 20 feet rise in height.

In the event dewatered wastewater solids are subjected to precipitation prior to placement, blend it with ash to improve its shear strength and compaction. The shear strength of 60/40 dewatered wastewater solids to ash blend is significantly higher than for dewatered wastewater solids alone.

Section 3
Operating Equipment

Landfill No. 3 will be operated with a mid-size bulldozer. Support equipment will consist of over-the-road transport vehicles, including standard dump trucks and rolloff container trucks. A motor-grader will be used for road maintenance, but will not necessarily be dedicated to the landfill operations.

In general, a bulldozer will be used to spread waste and compact the working face. The bulldozer will be used to maintain access from the perimeter road to the operating area, and to spread soil-like waste materials over blowing waste.

Hauling equipment operating outside the landfill area will be washed in a wash down area located at the dewatering press building. Wash water will be collected and treated with the landfill leachate and the dewatering press filtrate.

Operating equipment will be included in Domtar's preventative maintenance program. Routine maintenance, such as oil and filter changes, as well as sampling and analysis of lubricating and hydraulic oils will be conducted on schedules set in the program. Spare parts will be carried in inventory. If extended service should be required on the landfill bulldozer, a substitute bulldozer will be provided by other operations at the Domtar mill or leased from a local contractor to ensure continuous operations.

Section 4
Pumps

Redundant submersible pump systems remove leachate from the bottom of the landfill and transfer it by force main to the storage tank/sump of the leachate transfer station, then to the mill wastewater treatment system. Maintenance of the pumps will be conducted in accordance with manufacturer's recommendations.

Maintaining a strict set of operational checks and balances is crucial to the success of all landfill operations. A daily record of flow rates and total volumes will be used in troubleshooting the system. If flow is lower than anticipated, the system should be thoroughly inspected and any problems should be repaired - a pump may be down, the line may be clogged, or the leachate collection layer may be impeded by an impermeable waste stream. The flow meter should be routinely monitored and placed on a preventative maintenance (PM) schedule. The pumps should also be placed on a PM schedule. This will allow water to be removed as designed and the overall storage capacity of the cell for the major storm events to be maintained.

Section 5
Dust Control

Due to the frequent use of ash as daily cover and the potential for dusting, dust control equipment will be used at the Landfill. This equipment will consist of a pump and piping system tied to the leachate transfer station storage tank or wet well. Leachate will be pumped from the storage tank or wet well to mobile sprinkler units located within the landfill. The ash will be sprayed as needed to control dust, and as frequently as on a daily basis.

Section 6
Litter Control

A portion of the waste disposed of in the landfill will be compacted and uncompacted paper from the Domtar Complex paper manufacturing operations. This waste type will be dumped at the edge of the operating area. The waste material will be compacted by repeated passes of the compactor or bulldozer. Each day, or more frequently if required by weather conditions, blowing waste will be covered with soil-like waste materials or soil if suitable wastes are unavailable. Cover material will be available from a stockpile area. If necessary, litter-control fencing will be used to prevent litter from blowing beyond the landfill area.

Section 7
Stormwater Controls

Landfill operations will be conducted in a manner to minimize infiltration into the waste fill for two reasons:

- Excess moisture will reduce the stability of the fill by lowering the shear strength of the waste materials.
- Excess moisture will result in the generation of unnecessary quantities of leachate and increase the hydraulic head on the landfill liner.

Surface water runon will be prevented by the perimeter ditch and berm around the landfill, and by the cell delineation berms at the south end of each construction stage. The waste fill will be graded to minimize infiltration of contact rainwater. The operating area must be nearly level to function as a turnaround and dumping area for waste transport vehicles. The working face and operating area will be kept as small as practical, and will be sloped or crowned so that water drains from the surface to the leachate collection sand layer at the toe of the waste fill. Ponding of water will not be allowed. Depressions in the operating area will be filled with waste materials to promote runoff. The working face of the fill will be maintained at a slope of 3 horizontal to 1 vertical up to 5 horizontal to 1 vertical to promote runoff to the leachate collection sand layer at the toe of the slope.

Temporary stormwater control berms will be constructed in unfilled areas of the active cell to divert clean stormwater away from the leachate collection system. The berm will be located to provide adequate storage space for waste as well as temporary storage of runoff from the working face. It will also be sited to maximize segregation of stormwater and leachate.

Leachate will be collected in a series of sumps equipped with both primary and secondary submersible pumps. It is anticipated that during normal landfill operations the pumps will cycle to minimize pump burnout. In the event of an extraordinary rainfall event, primary and secondary pumps will be active thereby minimizing the amount and holding time of leachate within the landfill.

The following stormwater and leachate management practices will be maintained at the landfill:

- Diversion of non-contact stormwater away from the leachate system and removal of surface water discharge outside the landfill boundary. This can be accomplished via temporary internal diversion berms within the landfill and the use of portable pumps, if necessary. Internal berms are most important in the initial time period after the landfill is opened because extreme leachate generation rates are more likely. Although, the landfill system with internal stormwater diversion berms will allow for temporary storage/handling of the leachate generated from a 25-year, 24-hour storm event, it is crucial to separate and discharge non-contact stormwater before it is considered leachate. The pumps are sized to take up to 6 days to discharge leachate generated from the 25-year, 24-hour storm event.

- Limitation of the active filling area of the landfill to a small area to minimize the volume of leachate generated. This area is typically 5 acres or less depending on specific site conditions.
- Maintenance of a filling sequence that reaches final waste grades as soon as possible so that final cover soils can be placed to further divert surface water.
- Proper maintenance, operation, and monitoring of the leachate pumps, pump controls, discharge piping, leachate collection piping, and clean-outs.

Section 8
Site Facilities

Telephone, potable water, and toilets will be available in the dewatering press building. Back-up communication to and from the site will be provided by radio or cellular telephone. Since the dewatering press building is located in the area set aside for asbestos waste disposal, it will ultimately be demolished at closure of the landfill when it is no longer needed.

Section 9
Final Cover

Final cover will be progressively placed on areas of the landfill that have been graded to final contours. Cap construction will typically be performed in areas of 5 acres or less. Final grading and cap construction will proceed from north to south and west, as the fill reaches final grades. The cap for the Landfill includes GCL and a VFPE liner. These materials will be protected from the elements and operating equipment by a vegetative soil layer. Maintenance of the vegetative layer is critical to protect the integrity of the landfill cap system.

The cap will be sown according to approved seeding specifications for perennial vegetation. Vegetated cap areas will be mowed at least annually using equipment that will not damage the integrity of the soil cover layer. Vegetated areas will be inspected during the course of landfill operations. Conditions that may require repair include the following:

- Sparse or unhealthy vegetation
- Improper vegetation, such as trees or woody shrubs
- Erosion of the soil cover layer
- Slope failures, such as soil creep and sloughing
- Rutting from vehicular traffic or equipment operation

Damaged areas will be repaired as weather permits.

Section 10
Inspections

The landfill operator or designated inspector will conduct inspections of all landfill operating systems on a routine basis. Inspections will be conducted and documented using an inspection log. A typical example is included as Table 10-1.

Table 10-1
Sample Landfill Inspection Checklist

INSPECTION CHECKLIST	INSPECTION	INITIAL AND DATE THE APPROPRIATE BOX									
		S	M	T	W	T	F	S	STORMS	MONTHLY	QUARTERLY
Pumps											
1	Daily - check flashing light and standing water. Weekly - switch on and check current.										
2											
3											
4											
Ditches	Inspect monthly and after storms.										
Sediment Basin	Inspect monthly and after storms.										
Dikes and Berms	Inspect monthly and after storms.										
Fence and Gates											

Comments:

Work Orders Placed:

DATE	ORDER NUMBER	DESCRIPTION OF REQUEST

Appendix N
Closure/Post-closure Plan

ENVIRONMENT • ENERGY • ENGINEERING

Phase 3 and Phase 4 - Closure/Post-closure Plan

On-site Industrial Waste Landfill No. 3

Domtar Paper Company, LLC (Formerly Weyerhaeuser Company),
Plymouth, North Carolina

June 2008, Revised August 2009

RMT North Carolina, Inc. | Domtar Paper Company, LLC
Phase 3 and Phase 4 - Closure/Post-closure Plan

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CREATING BALANCE℠

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List of Attachments

Section 1
Introduction

This technical narrative addresses the closure and post-closure care requirements as identified in the NC DENR Solid Waste Management Rules, Section .1629 as related to closure/post-closure activities for the Domtar Landfill No. 3 in Plymouth, North Carolina. The requirements have been addressed in the format suggested in Section .1629.

1.1 Related Documents

This closure plan and cost estimate are included as an appendix to the construction plan application for on-site industrial process waste Landfill No. 3. It is to be used in conjunction with the following:

- CQA plan (Appendix Q)
- Sheet No. 11 FINAL GRADING PLAN – PHASE 1A AND 1B
- Sheet No. 12 FINAL GRADING PLAN - OVERALL
- Sheet No. 13 PHASE PROGRESSION PLAN
- Sheet No. 16 LEACHATE COLLECTION AND REMOVAL SYSTEM DETAILS
- Sheet No. 20 EROSION CONTROL DETAILS
- Construction specifications (to be issued immediately prior to cap construction)

Section 2
Background and Location

Industrial solid waste generated from manufacturing operations at the Domtar Plymouth Complex will be disposed of in the landfill. The waste streams include, but are not limited to, boiler ash, grits, liquor dregs, lime mud, wood wastes, paper wastes, pulp rejects, general mill trash, and dewatered wastewater treatment plant solids. Off-site waste material will likely be accepted from other Domtar mills only. Waste streams from these mills will be limited to those listed above.

The proposed 96-acre site is located approximately 2 miles south of the Domtar Complex as shown on Sheet No. 1. The site is generally located west of Ken Trowbridge Road; south of the Domtar Complex and the Roanoke River; east of Welch Creek; and north of Highway 64.

Section 3
Final Cover Design and Construction

Closure activities for the Domtar landfill will include the following items:

- Installation of intermediate cover
- Installation of the cap system
- Establishment of the vegetative cover

3.1 Permitted Final Cover Design

3.1.1 Installation of Intermediate Cover

Intermediate cover will consist of 12 inches of select waste (ash). This layer will serve as a smooth support layer for the GCL. The intermediate cover will be placed at Domtar's discretion on the waste in areas that have reached final grade elevations, and may be removed and stockpiled for future use before capping activities begin.

3.1.2 Installation of the Cap System

The largest area of the landfill requiring cover at any time during the life of the landfill is for a premature closure condition and is estimated to be approximately 19 acres. The estimated total volume of the landfill is 10.7 million cy. Prior to beginning closure of the landfill, a notice of intent to close the unit will be submitted to NC DENR and placed in the site operating record.

The proposed cap system for final cover will consist of the following components (top to bottom) as shown on Sheet No. 17:

- 6-inch vegetative layer
- 12-inch vegetative support layer
- Geotextile/geonet/geotextile composite (drainage layer)
- 40-mil VFPE geomembrane
- GCL

The minimum slope of the final cap will be 5 percent with the exception of a small area at 3 percent. The maximum slope of the final cap will be 33 percent. Benches, 15 feet in width, will be graded into the final cap slope at vertical intervals of 20 feet. The benches will have a minimum slope of 0.5 percent to collect storm water from the cap and to provide equipment access along the face of the landfill for maintenance and inspections.

Prior to beginning capping activities, any remaining fine grading of the intermediate cover will be conducted. Gas collection trenches and vents will be placed at the crest of the landfill. Next, the GCL will be placed to provide an impermeable layer that will reduce storm water infiltration into the waste and thereby reduce leachate production.

A 40-mil, VFPE-textured liner will be placed on the GCL to enhance the barrier layer. Refer to the CQA plan for VFPE acceptance specifications (see Appendix Q). A drainage composite consisting of a geotextile/geonet/geotextile will be placed over the textured membrane. Refer to the CQA Plan for geonet and geotextile acceptance specifications. This drainage layer will collect infiltration and divert water to the drainage terraces.

The final component of the cover system will consist of general fill and topsoil. The general fill layer will consist of 12 inches of soil or a mixture of dewatered wastewater solids and ash, as previously approved by NC DENR. The topsoil will consist of 6 inches of soil capable of sustaining vegetative growth. The sedimentation pond will be cleaned of sediment build-up and the sediment, consisting of material eroded from the existing cover, may be blended into the vegetative layer. Final grading of this layer will be accomplished with tracked equipment.

Within 90 days after completion of final grading requirements of the landfill unit, a seed bed will be prepared in the vegetative layer prior to applying seed and mulch. The seed bed will be prepared with a disc harrow penetrating to a minimum depth of 2 inches. Large clods, rocks, or other foreign material brought to the surface during preparation of the seed bed will be removed prior to the application of fertilizer, seed, and mulch. Fertilizer will be evenly spread over the surface of the prepared seed bed and worked into the soil with one final light pass with a disk harrow or a chain harrow. Lime will be applied, if necessary, to enhance growth.

Permanent vegetation will be established by spreading seed with a mechanical device that ensures an even application rate of the seed mixture. The vegetative components may be applied simultaneously with a hydroseeder.

The following method is suggested for establishing the permanent vegetation:

1. Apply liming agent at recommended rate.
2. Apply fertilizer (10-10-10) at recommended rate.

3. Work lime and fertilizer into the soil.
4. Apply seed mixture at recommended rates.
5. Apply mulch to the seeded surface.
6. If final grading and surface preparation are delayed due to inclement weather, appropriate measures will be taken to remedy any effects of erosion.
7. Maintenance measures will be performed as necessary to achieve a thorough coverage of vegetation.

3.2 Construction Specifications

Prior to the commencement of closure activities, applicable construction specifications will be issued for NC DENR review. In the interim, the CQA plan located in Appendix Q of the permit application will provide any necessary information regarding the cap components and their required properties.

3.3 Quality Assurance/Quality Control

Construction quality assurance (QA) and quality control (QC) during all landfill closure activities will be performed according to the CQA plan (Appendix Q of the permit application). The CQA plan was written in accordance with Section .1621 of the NC DENR regulations and will form part of this document as referenced. Prior to closure, the CQA plan will be reviewed and modified as necessary and attached to this closure plan and cost estimate.

3.4 Erosion Control Measures

State and federal erosion control regulations will be followed during closure activities. Prior to establishing vegetation, areas left disturbed for a period greater than 14 days will be covered with jute mesh, temporary vegetation, or an equivalent cover. Other standard management practices for erosion control such as silt fencing, hay bale barriers, etc., will be employed as necessary. In addition, storm water from the cap areas will be routed through the sediment ponds located around the landfill, which will serve to remove suspended sediment.

Section 4
Closure Scenarios

4.1 Routine and Premature Closure

The disposal site will be developed in 18 phases as shown on Sheet No. 13. This operating scenario shown is based on utilizing the working face method of fill and allows for the lateral expansion of the facility in the future. As waste is placed in the active stage, it will be graded, spread, and compacted along the working face. As final subgrade elevations are reached, the working face will move to the south, into the next lined phase. Next, either the finished areas will be covered with a temporary cover, which will minimize the generation of leachate, or a final cover will be constructed.

Prior to construction of the final cap, surface water that comes into contact with waste will be managed as leachate. Surface water runoff from areas of vegetated intermediate cap will be discharged through appropriate sedimentation controls.

With the exception of Phase 1 and Phase 2, which occupy a footprint area of approximately 14 and 15 acres, respectively, each of the landfill's 18 phases covers approximately 5 acres. Phase 3 and Phase 4 have a combined life expectancy of approximately 5 years (*i.e.*, until other phases have to be opened to accommodate leachate generated by stormwater runoff).

Final cap construction will proceed from phase to phase. As Phase 3 and Phase 4 near capacity, the Phase 5 and Phase 6 cells will be constructed to provide temporary containment for leachate generated from stormwater runoff. Phase 3 and part of Phase 4 will then be capped as filling continues in Phase 4 to minimize the generation of leachate. Construction will proceed in this manner through the life of the landfill.

4.2 Closure Cost Estimate

For purposes of meeting NC DENR financial assurance requirements, the cost to close the intermediate 19-acre cell was calculated to be approximately $2.6 million (Attachment 1). This estimate includes the estimated cost for Domtar to hire an independent third party as general contractor (not a corporate subsidiary or parent, or affiliate of the permittee) to perform each task, including the costs of preparing and executing bid documents for the selection of a general contractor and supervising the general contractor's performance.

Unit costs are based on information from contractors in the southeastern United States, vendor estimates, published costs, or engineering estimates. Costs reflect a rate of return of 5 percent and an inflation rate of 4 percent. Specific cost allowances are not included for interest during construction, legal fees, financial consultants, debt service, or equipment depreciation. Closure costs include an administrative allowance of 20 percent of the capital cost plus a general contingency of 40 percent.

The following is a description of those closure items in Attachment 1 that may require explanation.

4.2.1 Control Grading

This item includes relocating waste, surface preparation, and obtaining proper surface elevations. Erosion control measures are shown as separate line items.

4.2.2 Geosynthetic Clay Liner

This item includes placing GCL for the low permeability layer of the final cover.

4.2.3 40-mil Textured Very Flexible Polyethylene Geomembrane

This item includes obtaining and installing 40-mil textured VFPE geomembrane for the final cover.

4.2.4 Geonet Drainage Composite

This item includes obtaining and installing geonet drainage composite for the final cover.

4.2.5 Vegetative Support Layer

This item includes placing fill material for the vegetative support layer and assumes that all necessary material will be available from an on-site stockpile. The cost for this item is based on in-place volumes.

4.2.6 Topsoil

This item includes placing topsoil for the final cover and assumes that all necessary material will be available from an on-site stockpile. The cost for this item is based on in-place volumes.

4.2.7 Vegetation

Establishing a vegetative cover includes the following items:

- Soil testing

- Amending soil with lime, fertilizer, and organic matter
- Incorporating soil amendments, including disking, harrowing, sprigging, and herbicide application
- Spreading and disking surface thatch

4.2.8 Closure Survey

This item includes survey of the entire closure area to determine final elevations of the cap. The cost to prepare a drawing of the final elevations showing contour intervals at 2-foot contours is included as a separate item.

4.2.9 Administrative Costs

Administrative costs shown as 20 percent of the total capital cost include the following items:

- Redesigning final closure, if necessary, in accordance with existing site conditions and applicable regulations
- Contracting for technical consulting services
- Providing administrative overhead for oversight
- Preparing final closure certification
- The costs for an independent third-party consultant for all services associated with preparing and executing bid documents, selection of an independent third-party construction contractor, and supervision of the contractor's general performance

4.3 Maximum Waste Inventory

It is expected that over the entire life of the facility, the maximum waste inventory will be approximately 10.7 million cy. The maximum waste inventory in Phase 3 and Phase 4 will be approximately 506,000 cy.

Section 5
Closure Schedule

It is expected that closure for this scenario would not require longer than 180 days. However, if the project were to exceed this duration, Domtar would take the steps necessary to prevent threats to human health and the environment from the unclosed landfill unit. The closure period would be extended only with NC DENR approval. In addition, closure activities for the landfill unit would be completed in accordance with this plan.

Section 6
Closure Certification and Deed Notation

Following closure of the landfill unit, Domtar will submit to NC DENR a certification, signed by an independent registered professional engineer verifying that closure has been completed in accordance with the closure plan, and a copy placed in the site operating record. In addition, within 90 days after closure activities are complete, Domtar will record a notation onto the land deed and/or some other legal instrument that is normally examined during a title search stating that the property has been used as a solid waste disposal facility landfill unit. The notation will include the following information:

- The land has been used as a solid waste disposal facility landfill unit.
- The land use is restricted to ensure that the cap system integrity or other containment components are not compromised, and monitoring systems are not disturbed.
- That any re-use of the property will not increase the potential threat to human health or the environment.
- The name of the permittee, the type of disposal facility, and the beginning and closure dates of the disposal activities will be included.
- The locations and dimensions of the landfill unit with respect to permanently surveyed benchmarks and section corners on a plat prepared and sealed by a land surveyor will be included.
- The notation will be certified by an Engineer or Land Surveyor stating that all closure requirements have been completed as determined necessary by the Department.

Domtar will submit a certified copy of the recording instrument to NC DENR and place a copy in the operating record within 120 days after permit expiration, revocation, or as otherwise directed by NC DENR.

Section 7
Post-closure Monitoring and Maintenance

7.1 Final Cover Maintenance/Inspection Schedule

The finished cap and perimeter berm will receive a visual inspection on a weekly basis to check for and document evidence of settling, subsidence, erosion, and other potential failures of the final cover. These inspections will also encompass the perimeter berm, ditches, channels, and sediment basin to ensure storm water runoff and runon are being properly routed. These inspections, along with any repairs that were required, will be documented and maintained on file by Domtar.

In addition, the landfill will be mowed at least once per growing season, and fertilized and reseeded as necessary. This will protect the final cover against erosion and decrease the potential for leachate generation. Vegetation that poses a threat to the integrity of the final cover, such as deep-rooted shrubs and trees, will be removed.

7.2 Leachate Collection System/Miscellaneous Maintenance

Domtar will perform the following maintenance activities for the duration of the post-closure care period:

- **Pumps**. Proper maintenance of this equipment is critical to the operation of the leachate collection and transfer system. The manufacturer's recommendation for routine inspection and cleaning intervals will be followed for pumps and pump controls, with pump inspections occurring no less than once per week. The collection piping will be jet cleaned at least annually. In addition, all valves and flow measurement devices will be inspected and cleaned as necessary on a regular basis.
- **Leachate Treatment**. Leachate collected in the wet well of the leachate transfer station will continue to be treated in the mill wastewater treatment system for the duration of the post-closure period. Leachate collection may be discontinued if testing establishes that leachate treatment is no longer necessary and upon approval of NC DENR (see Subsection 5.6.2 of the permit application).
- **Access Control**. Access to the landfill facility will be controlled by secure fencing for the duration of the post-closure period.

7.3 Groundwater Monitoring System

Groundwater will continue to be monitored as described in Subsection 5.6.1 and in Appendix O, Sampling and Analysis Procedures for Groundwater, of the permit application for the duration of the post-closure period.

7.4 Gas Monitoring

Gas monitoring at the site will not be performed at the landfill due to the predominantly inorganic nature of the wastes, as discussed in Subsection 5.6.3 of the landfill permit application document.

Section 8
Post-closure Cost Estimate

The post-closure cost estimate was based on monitoring and maintaining Phase 3 and Phase 4 of the disposal facility for a period of 30 years after final closure. This estimate is included as Attachment 2. Unit costs are based on information from contractors in the southeastern United States, vendor estimates, published costs, or engineering estimates. Costs reflect current pricing. The present value of post-closure care for Phase 3 and Phase 4 is estimated to be $2.8 million (see Attachment 2), assuming a 5-year life for Phase 3 and Phase 4, a 30-year post-closure care duration, 4 percent inflation rate, and 5 percent interest rate. Specific cost allowances are not included for interest during construction, legal fees, financial consultants, debt service, or equipment depreciation. Post-closure costs include an administrative allowance of 20 percent of the capital cost plus a general contingency of 40 percent.

8.1 Routine Inspection

This item is for inspecting the site twice each year for 2 years to determine the necessary maintenance required.

8.2 Maintenance of On-site Improvements

This item is for repair and maintenance of all on-site permanent improvements and equipment including signs, gates, fences, roads, or other structures necessary to maintain closure of the site.

8.3 Maintaining Vegetation

The cost is included to mow the site two times per year, reseeding as necessary, and applying weed control measures.

8.4 Repair of Final Cover

This item is for controlling erosion, settlement, and ponding on the final cover.

8.5 Maintaining Surface Drainage Features

This item includes the cost of repairing erosion for 10 percent of the total ditch length per year.

8.6 Groundwater Monitoring Well Sampling

The cost is included to sample and analyze one sample per year for each of the 12 monitoring wells in accordance with the groundwater monitoring, sampling, and analysis plan for the duration of the post-closure period.

8.7 Leachate Collection System Maintenance

The cost is included to maintain the two additional leachate pumps in Phase 3 in accordance with manufacturer's recommendations. This cost was derived by multiplying the capital cost of the pumps by 10 percent representing the depreciation of each pump over its useful life.

8.8 Administrative Costs

Administrative costs shown as 20 percent of the total capital cost include the following items:

- Record keeping
- Contracting for technical consulting services
- Administrative overhead for oversight
- Preparing post-closure certification
- The costs for an independent third-party consultant for all services associated with preparing and executing bid documents, selection of an independent third-party construction contractor, and supervision of the contractor's general performance

8.9 Post-Closure Costs Not Included

No allowance has been made for the following items:

- Air sampling
- Soil sampling
- Surface water sampling
- Gas sampling
- Monitoring well abandonment
- Leachate treatment

Section 9
Contact Persons

The following office can be contacted during the post-closure period:

Environmental Manager
Domtar Paper Company, LLC
Plymouth Mill
West Main Street Extension
PO Box 747
Plymouth, North Carolina 27962
(252) 793-8111

Section 10
Landfill Property Use

Currently, there are no planned uses of the property during the post-closure period. In the event a use is realized, NC DENR will be contacted for approval. All proposed activities will be restricted to prevent damage to the integrity of the final cover, liner, and all other components of the containment system.

Section 11
Post-closure Certification

Following completion of post-closure care and verifying that post-closure care has been completed in accordance with this post-closure plan, Domtar will notify NC DENR that a certification, signed by a registered professional engineer, has been placed in the operating record.

Attachment 1
Opinion of Probable Costs
Landfill No. 3 Closure,
Phase 3 and Phase 4 Cost Estimate

Attachment 1

OPINION OF PROBABLE COSTS					
CLOSURE OF LANDFILL NO. 3, PHASE 3 AND PHASE 4				By:	JLH
DOMTAR PAPER COMPANY, LLC, PLYMOUTH, NORTH CAROLINA				Checked:	RKN
RMT PROJECT NO. 00-71717.10				Date:	2/11/2008
	Footprint (acres):	8.68	Disposal Rate (cyds/year):		155,464
	Volume (cyds):	581,453			
	Waste Unit Weight (lbs/cf):	70			
	Phase Operations (years):	4	Post-Closure Care (years):		30
	Rate of Return:	5%		Inflation:	4%

DESCRIPTION: Closure of Phase 3 and Phase 4 (approximately 8 acres)

ITEM NO.	*ITEM DESCRIPTION*	*QUANTITY*	*UNITS*	*UNIT COST*	*TOTAL COSTS*
1.00	**CONSTRUCT MULTILAYERED CAP**				
1.01	CONTROL GRADING	42,011	SY	$ 3.25	$ 136,536
1.02	SELECT ASH (1-FT THICK)	14,004	CY	$ 5.00	$ 70,019
1.03	GCL	378,101	SF	$ 0.74	$ 279,795
1.04	40-MIL TEXTURED VFPE MEMBRANE	378,101	SF	$ 0.46	$ 173,926
1.05	GEONET COMPOSITE	378,101	SF	$ 0.73	$ 276,014
1.06	PASSIVE GAS SYSTEM	2,060	LF	$ 50.00	$ 103,000
1.07	VEGETATIVE SUPPORT LAYER	16,104	CY	$ 5.00	$ 80,521
1.08	TOPSOIL (6 INCHES THICK)	8,052	CY	$ 5.00	$ 40,261
1.09	FINAL GRADING	42,011	SY	$ 3.25	$ 136,536
1.10	SEEDING, FERTILIZING, & MULCHING	9	ACRE	$ 3,000.00	$ 26,040
2.00	**EROSION CONTROL**				
2.01	SILT FENCING	5,000	LF	$ 3.75	$ 18,750
2.02	SEDIMENT TRAPS	2	EA	$ 1,700.00	$ 3,400
2.04	TEMPORARY DIVERSION DITCHES (QUANTITY ALLOWANCE)	2,500	LF	$ 4.00	$ 10,000
2.05	RIP RAP (QUANTITY ALLOWANCE)	500	TON	$ 35.00	$ 17,500
3.00	**SURVEYING**	9	ACRE	$ 2,700.00	$ 23,436
	SUBTOTAL				***$ 1,395,734***
4.00	**MOBILIZATION (5 % OF CONSTRUCTION)**	1	LS	$ 69,786.71	$ 69,787
5.00	**DEMOBILIZATION (1% OF CONSTRUCTION)**	1	LS	$ 13,957.34	$ 13,957
6.00	**ENGINEERING SERVICES**	1	LS	$ 50,000.00	$ 50,000
7.00	**CONSTRUCT.MGMT. SVCS. & CERTIFIC. RPT. (10% OF CONSTRUCTION)**	1	LS	$ 139,573.42	$ 139,573
	SUBTOTAL				***$ 1,669,052***
8.00	**ADMINISTRATIVE (20% OF CAPITAL COSTS)**				$ 333,810
9.00	**CONTINGENCY (40% OF CAPITAL COSTS)**				$ 667,621
	TOTAL CAPITAL COST ESTIMATE				***$ 2,670,483***
	PER ACRE CAPITAL COST ESTIMATE				*$ 307,659*
	TOTAL PRESENT VALUE CAPITAL COST ESTIMATE				**$ 2,566,281**

Attachment 2
Opinion of Probable Costs
Landfill No. 3 Post-closure,
Phase 3 and Phase 4 Cost Estimate

Attachment 2

OPINION OF PROBABLE COSTS						
POST-CLOSURE, LANDFILL NO. 3 PHASE 3 AND PHASE 4					By:	JLH
DOMTAR PAPER COMPANY, LLC, PLYMOUTH, NORTH CAROLINA					Checked:	RKN
RMT PROJECT NO. 00-71717.10					Date:	2/11/2008
		Footprint (acres):	7.96	Disposal Rate (cyds/year):		155,464
		Volume (cyds):	581,453			
		Waste Unit Weight (lbs/cf):	70			
		Phase Operations (years):	4	Post-Closure Care (years):		30
		Rate of Return:	5%		Inflation:	4%
DESCRIPTION: Post-closure of Phase 3 and Phase 4 (approximately 8 acres)						
ITEM NO.		*ITEM DESCRIPTION*	*QUANTITY*	*UNITS*	*UNIT COST*	*TOTAL COSTS*
1.00		**ROUTINE INSPECTION (2 TRIPS PER YEAR)**	2	EACH	$ 3,000.00	$ 6,000
2.00		**MAINTENANCE OF ON-SITE IMPROVEMENTS**	1	YEAR	$ 7,500.00	$ 7,500
3.00		**MONITORING WELL ABANDONMENT**	-	EACH	$ 1,000.00	$ -
4.00		**MAINTAIN VEGETATION (19 ACRES AT**	8	ACRE	$ 300.00	$ 2,388
		$300/ACRE/YEAR)				
5.00		**REPAIR FINAL COVER**	1	YEAR	$ 3,000.00	$ 3,000
6.00		**MAINTAIN SURFACE DRAINAGE FEATURES**	1	YEAR	$ 6,000.00	$ 6,000
		(1500 FT AT $4/LF/YR)				
7.00		**MAINTAIN LEACHATE COLLECTION**				
7.01		MAINTENANCE OF LEACHATE PUMPS (10% OF	6	PUMP	$ 2,700.00	$ 16,200
		CAPITAL COST/PUMP/YEAR)				
8.00		**GROUNDWATER SAMPLE ANALYSIS**	12	EACH	$ 2,000.00	$ 24,000
		(1/YEAR/PHASE FOR 12 WELLS)				
9.00		**GROUNDWATER SAMPLE COLLECTION**	1	TRIP	$ 2,500.00	$ 2,500
10.00		SUBTOTAL				$ 67,588
11.00		ADMINISTRATIVE (20% OF CAPITAL COSTS)				$ 13,518
12.00		CONTINGENCY (40% OF CAPITAL COSTS)				$ 27,035
13.00		**TOTAL POST-CLOSURE CAPITAL COST ESTIMATE PER YEAR**				**$ 108,141**
13.01		TOTAL POST-CLOSURE CAPITAL COST ESTIMATE PER ACRE				$ 13,586
14.00		**POST-CLOSURE ESTIMATE PRESENT VALUE**				**$ 2,688,912**

Appendix O
Sampling and Analysis Procedures for Groundwater

Sampling and Analysis Procedures for Groundwater

General Information

Sample bottles will be shipped to the site in sturdy, durable shipping coolers.

Type 1 reagent grade water will be used that meets ASTM, CAP, and NCCLS standards.

Field activities will be documented in a bound field book or on a field collection sheet. The following information will appear on each page: project, date, time, sampler's initials, site contact, conductivity, well depth, temperature, water level, gallons purged, and pH.

Existing monitoring wells are fitted with dedicated QED low flow purge system bladder sampling pumps and water level meters (or equivalent). The dedicated pumps will be used to purge well volumes and collect groundwater samples. Proposed monitoring well MW-13 will also be fitted with a dedicated QED sampling pump (or equivalent) and an electric water level meter.

In most cases, a field team will consist of two technicians. The field team will check equipment before departing for the site. Water extracted from the wells that is not used for sample volume will be discarded on the land surface in the vicinity of the well.

Equipment Decontamination

Dedicated QED sampling pumps and water level meters (or equivalent) will remain in the wells. No equipment will require removal prior to measuring water levels and sampling. This equipment will be shipped to the site pre-cleaned. Therefore, decontamination of pump equipment at the site will not be necessary.

Though the wells are to be equipped with dedicated pumps, it may be necessary at times to use non-dedicated equipment (for example, dedicated pumps out of service) to purge and sample wells. Such groundwater sampling equipment that will come into contact with the sample will be cleaned according to a specific procedure. Equipment will be washed with laboratory detergent and water, followed by a tap water rinse. Stiff brushes may be used to remove gross debris. Cleaning procedures may be augmented with the use of a high-pressure sprayer to remove debris, assist with the detergent wash, and perform the tap water rinse. The equipment will then be rinsed three times with deionized, organic free (*i.e.*, Type 1 reagent grade) water, and allowed to air dry. After rinses with deionized, organic free water, equipment will be rinsed with isopropanol, and allowed to air dry. Any equipment that is not to be used immediately after decontamination will be wrapped in aluminum foil, then stored in a manner and location that minimizes the risk of contamination.

Teflon® Bailer Cleaning Procedure

(This procedure is approved for use under both Solid Waste Section and Groundwater Section rules.)

1. Disassemble the bailers, and rinse the parts with tap water. Place the end caps and ball in a phosphate-free soap solution to soak.
2. Wash the bailer tubes with phosphate-free soap. Use a brush to scrub the insides of each tube.
3. Rinse all bailer parts with deionized water and reassemble.
4. Rinse the inside and outside of each bailer with a 10 percent solution of nitric acid in deionized water.
5. Rinse bailers with deionized water.
6. Rinse the inside and outside of each bailer with isopropyl alcohol.
7. Let bailers air dry for 24 hours on shelf.
8. Wrap completely in aluminum foil (shiny side out).
9. Place foil-wrapped bailer in plastic sleeve, and seal with tape.

Water Levels

A procedure for obtaining water levels will be used that maximizes accuracy of measurement, reduces the risk of exposure to potentially contaminated groundwater, and reduces the potential for cross contamination. The well cap will be removed and the well allowed to vent. Tightly sealed wells will not respond well to variation in the water table due to a "straw effect" caused by air trapped in the well casing. Venting the well will allow the water level in the well to equilibrate and become representative of the piezometric surface. Measurements will be made to the nearest hundredth of a foot.

The wells will be equipped with dedicated water level indicators. The dedicated water level indicators will be stored at least 5 feet above the mean seasonal high water level within the well. In the event that the dedicated water level indicator cannot be used, a portable water level indicator will be used. The operation of the portable electric water level indicator will be checked before introducing it into the well. The probe will be lowered slowly into the well until the buzzer sounds or a light illuminates to indicate the probe is in the water. Depth to water will be measured from the point on the cable touching the surveyed measuring point at the top of the well casing.

To reduce the possibility of cross contamination, the portable water level indicator probe and any cable that entered the well must be decontaminated as indicated by site-specific requirements before the next water level will be taken.

Pressure transducers and data loggers may also be used to record water levels over extended periods of time.

Purging Wells

Water that has remained in a well casing for a period of time may not be representative of the water contained in the surrounding formation that the well is intended to sample. To obtain samples that are representative of water in the formation, wells will be purged of the water in the casing and surrounding sand pack to allow water from the formation to enter the well casing for sampling. The wells will be purged slowly to reduce turbidity and the potential for suspended sediment in the sample.

Water will be purged slowly from a well until specific conductance, pH and temperature stabilize. A minimum of three well volumes will be purged from the well unless the well is bailed dry. In the latter case, no further purging is necessary. A "well volume" is the volume of water contained in the well at the time of sampling. A well volume will be purged using the dedicated sampling pump. As an alternative, the wells may be purged using a peristaltic pump with flexible tubing, or Groundfos® sampling pump (or equivalent), or using a clean bailer and cord. Unless otherwise specified, dedicated QED sampling pumps (or equivalent) will be used. The pump will be started at a low flow rate and the outflow will be directed into a bucket of known volume. The purpose of the low flow rate during well purging is to reduce turbidity resulting from disturbing sediment that may be present in the bottom of the well. Purge water will be measured based on the known volume of the bailer used or by pouring the contents into a container of known volume. Purge water will be discarded on the ground adjacent to the well.

As a second alternative to purging with the dedicated sampling pump, a bottom-filling Teflon® bailer may be used to purge the well. The bailer and cord should only touch the inside of the well or a clean surface provided specifically for that bailer and cord. Bailers will be gently lowered to the top of the water column and then gently removed to reduce turbidity.

The color, odor, turbidity, and any other comments pertaining to the purge water will be documented in the field log. After each well volume of water has been removed from the well, specific conductance, pH, and temperature of the water will be determined and recorded in the field log. After specific conductance, pH and temperature have stabilized, sample collection may begin.

Sampling of Wells

New monitoring well MW-13 will be sampled quarterly for four consecutive quarters beginning after the well has been installed. Following the fourth quarter, MW-13 will be sampled semiannually. Monitoring wells MW-2 through MW-6 and MW-6A and MW-7 will continue to be sampled at the frequency established for Landfill No. 2, and MW-9 through MW-12 will continue to be monitored at the frequency established for Landfill No. 3, Phase 1A.

Wells will be sampled using dedicated QED sampling pumps (or equivalent). The samples will be discharged directly to the sample containers. The sample bottles will be labeled with sample identification, date, and project number. Preservative will be added to the bottle prior to collecting the sample. Samples will be collected in the following order unless otherwise specified: volatile and organics; metals; sulfate and chloride; turbidity; and nitrate. This sequence is based on the preferred collection order listed in RCRA Groundwater Monitoring Technical Enforcement Guidance Document, September 1986.

In bottles where caustic preservative will be required (*i.e.*, samples for cyanide analysis), pH will be verified in the field by pouring some of the preserved sample over pH paper. If the proper pH has not been attained, more preservative will be added in the field. Samples requiring acid preservative will be checked with pH paper to determine if sufficient preservative has been added. More preservative will be added to the sample if necessary.

Well sampling sequence will be determined based upon available information about the site. The sequence will generally begin with background wells and wells upgradient of active and completed landfill phases, followed by wells downgradient of active or completed phases.

Sample Handling and Shipping

Immediately after sample collection, the sampler will check the label for completeness. Glass sample bottles will be wrapped in bubble wrap packaging to minimize the possibility of breakage. Samples will then be placed into a cooler containing ice. The chain-of-custody form will then be completed and stored with the samples inside the cooler in a plastic bag. Custody will be maintained by the sampler until the coolers are prepared for transport. The cooler will be filled with ice, sealed with tape, and shipped via overnight air freight or courier, or it will be delivered to the laboratory by field technicians.

References

Bouwer, H. and Rice, R. C., 1988, A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells, Water Resources Research, vol. 12, no. 3, pages 423-428.

National Water Well Association. “RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD): September, 1986.”

United States Environmental Protection Agency, Office of Research and Development. “Groundwater Handbook,” EPA/625/6-87/016, March, 1987.

United States Environmental Protection Agency, Region IV. “Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual (ECBSOPQAM): February 1, 1991.”

Appendix P
Construction Quality Assurance Plan Phase 3 and Phase 4 Construction – Landfill No. 3

Phase 3 and Phase 4 - Construction Quality Assurance (CQA) Plan

On-site Industrial Waste Landfill No. 3

Domtar Paper Company, LLC (Formerly Weyerhaeuser Company), Plymouth, North Carolina

June 2008

30 Patewood Drive, Suite 100 • Greenville, SC 29615-3535 • (864) 281-0030 • (864) 281-0288 FAX • www.rmtinc.com

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Section 1
Introduction

1.1 Project Background

This report presents the CQA plan for specific components of the composite liner and final cover for the Domtar Plymouth Landfill. The liner and cover area cover approximately 95 acres and will be developed on Domtar property located in Plymouth, North Carolina.

This plan addresses CQA requirements for modified liner and cover components of the landfill. Design-related aspects of the components mentioned above are addressed in the construction plan application. This CQA plan is a "working" document, which will be updated as necessary to reflect changes in specific materials used, in installation practices, or in tests and test methods.

1.2 Purpose and Scope

The purpose of this CQA plan is to provide procedures that will confirm that the landfill liner and cover are constructed and documented consistent with the construction plan application approved by NC DENR, and the construction drawings and specifications.

The scope of this report includes general CQA requirements concerning roles, responsibilities, and qualifications of parties involved; the preconstruction meeting; and general inspection and documentation procedures. Specific CQA requirements for each liner component address construction procedures and observation, field and laboratory testing frequency and methods, and acceptance criteria. Geomembrane testing and acceptance criteria are based on ASTM and the Geosynthetics Research Institute (GRI).

The general CQA requirements (Sections 2, 3, and 4) pertain to all liner components. The following report sections pertain to the landfill components as shown:

REPORT SECTION		LANDFILL COMPONENT
Section 5	Compacted Select Clay Fill	Clay soil liner (sump areas)
Section 6	Granular Materials	Leachate drainage blanket Pipe bedding material
Section 7	Geotextiles and Geocushion™	Component of Geocomposites Leachate collection bedding cushion

REPORT SECTION		LANDFILL COMPONENT
Section 8	Geomembranes	Geomembrane liner (landfill base and cap)
Section 9	Geonets	Component of Geocomposite
Section 10	Geosynthetic Clay Liner	GCL liner (landfill base and cap)
Section 11	Geocomposites	Drainage layer (final cover and alternate leachate drainage layer)
Section 12	Select Ash Fill	Protection layer (landfill base) Leveling course (final cover)
Section 13	Piping	Leachate collection and transfer piping Gas Collection piping
Section 14	Compacted Prepared Subgrade Fill	Prepared subgrade for landfill base liner

Section 2
Roles, Responsibilities, and Qualifications

2.1 Construction Quality Assurance Officer

The CQA officer shall supervise and be responsible for all inspections, testing, and related construction documentation as described in this CQA plan. The CQA officer will be responsible for preparation of the construction documentation report to certify substantial compliance with the engineering design. The CQA officer shall be a North Carolina Registered Professional Engineer.

The CQA officer may delegate daily inspection, testing, and sampling duties to a qualified technician with experience in the assigned aspect of construction who will serve as the resident project representative (RPR). Although these duties may be delegated, the CQA officer will retain the responsibility for these activities.

When an RPR is designated, the CQA officer shall visit the construction site biweekly (every 2 weeks) at a minimum during active periods of construction to personally observe the construction and documentation procedures. Also, at a minimum, the CQA officer shall personally observe, on at least one occasion, each of the major elements of construction including the prepared subgrade, the GCL, the geomembrane liner, and the leachate drainage layer. The CQA officer shall be readily available for consultation, as needed.

2.2 Resident Project Representative

The RPR will carry out daily inspection, testing, and sampling duties under the direct supervision of the CQA officer. The RPR shall be a qualified technician with experience in the assigned aspect of construction. The RPR will observe and document construction and installation procedures. The RPR will prepare daily summary and inspection reports and transmit these routinely to the CQA officer. The RPR will immediately notify the CQA officer of problems or deviations from the CQA plan or design plans and specifications. Reporting, documentation, and resolution of problems and deficiencies shall be carried out as described in Subsection 4.3. The RPR will ***not*** have authority to approve design or specification changes without the consent of the CQA officer.

2.3 Soils Testing Laboratory

The Soils Testing Laboratory retained will be experienced in landfill construction soils testing in accordance with the ASTM standards and other applicable standards. The selected laboratory will be required to be responsive to the project needs by providing test results within reasonable time frames. This shall include providing verbal communication on the status of ongoing tests and immediate communication of test results as needed to facilitate ongoing construction. Such information may include hydraulic conductivity test data, proctor values, and borrow source characterization data. Final laboratory reports will be certified by the soils testing laboratory and submitted to the CQA officer.

2.4 Geosynthetics Testing Laboratory

The Geosynthetics Testing Laboratory will have experience in testing geosynthetics in accordance with standards developed by ASTM, GRI, and other applicable test standards. The selected laboratory will be required to be responsive to the project needs by providing test results within reasonable time frames. Final laboratory reports will be certified by the geosynthetics testing laboratory and submitted to the CQA officer.

2.5 Construction Contractor

The construction contractor's role will be performed by a construction firm retained by the owner to furnish earthwork and piping construction. The construction contractor will be experienced in solid waste landfill construction, knowledgeable about clay liner construction techniques, and familiar with geosynthetic construction.

2.6 Geosynthetic Installers

The geosynthetic installers are the companies hired by the contractor to install the geosynthetic components referenced in this manual and to perform the nondestructive seam testing of the geomembranes required by this plan. The term "installer" is used throughout this plan when reference is made to the tasks and responsibilities of a geosynthetic installer.

The installer will be trained and qualified to install the various geosynthetic components covered by this plan. The installer of the geomembranes will be approved and/or licensed by the manufacturer. A copy of the approval letter or license will be submitted by the installer to the CQA officer.

Prior to confirmation of any contractual agreements, the contractor shall obtain from the installer of the geomembrane the following written information, which must be approved by the CQA officer:

1. Corporate background and information
2. Installation capabilities
    - Information on equipment and personnel

- Daily anticipated production
- QC manual for installation
- Samples of field seams and certified test results

3. A list of at least 10 completed facilities, totaling a minimum of 2,000,000 square feet (ft^2) for which the installer has completed the installation of a polyethylene geomembrane.

For each installation, the following information will be provided:

1. Name and purpose of facility, its location, and date of installation
2. Name of owner, project manager, designer, manufacturer, and fabricator (if any)
3. Name and qualifications of the supervisor(s) of the installer's crew(s)
4. Thickness of the geomembrane and the surface area of the installed geomembrane
5. Type of seaming and type of seaming apparatus used

All personnel performing geomembrane seaming operations will be qualified by experience or by successfully passing seaming tests for the seaming methods to be used. At least one seamer will have experience seaming a minimum of 1,000,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus in use at the site. The most experienced seamer, the "master seamer," will provide direct supervision, as required, over less experienced seamers. No field seaming will take place without an experienced seamer (meeting the seaming criteria stated above) being present.

The contractor shall require the installer to provide a list of proposed seaming personnel and their professional records. This document will be reviewed by the CQA officer. Any proposed seaming personnel deemed insufficiently experienced will not be accepted by the CQA officer or will be asked to pass a seaming test. Any changes in the list of seaming personnel shall be brought to the attention of the CQA officer.

The installer will designate one representative as the superintendent, who will represent the installer at all site meetings and be responsible for acting as the installer's spokesperson on site. This superintendent should be prequalified for this role, on the basis of experience, management ability, and authority. The appointment must be approved by the CQA officer.

Section 3 Preconstruction

3.1 Preconstruction Meeting

Prior to construction commencing at the landfill facility, a preconstruction meeting shall be held. This meeting will include the parties involved in the construction, including the CQA officer, RPR, construction and/or Installation contractor, and owner.

The objectives of this meeting include construction planning and coordination of tasks; identification of potential problems that might cause difficulties and delays in construction; and proper interpretation of design intent by contractor(s). It is important that the rules regarding testing, repair, etc., be known and accepted by each party to this plan.

Specific topics considered for this meeting include the following:

- Review general safety requirements of the owner and specific safety issues associated with the construction activities.
- Review critical design details of the project, including the plans and specifications.
- Review measures for surface water runoff and runon diversion control including sump locations, siltation control, and pumping requirements.
- Make appropriate modifications to the CQA plan; develop project-specific addendums (if necessary).
- Review the responsibilities of each party.
- Review lines of authority and communication.
- Review methods for documenting and reporting and for distributing documents and reports.
- Review requirements of the Soils Testing Laboratory and the Geosynthetics Testing Laboratory regarding sample sizes, methods of collection, and shipment. Also review turnaround times for sample data and implications on construction schedule pending receipt of acceptance data.
- Review the number and locations of the testing requirements for soils and geosynthetic components.
- Review precautions to be taken to maximize bonding between lifts of compacted clay.
- Review the method for splicing segments of compacted clay soil liner.
- Review precautions to be taken to minimize desiccation of clay soil surfaces.

- Review methods of subgrade surface preparation and approval prior to geosynthetic placement.
- Establish rules for writing on the geomembrane (*i.e.*, who is authorized to write, what can be written, and in which color); outline procedures for packaging and storing archive samples.
- Review the time schedule for all operations and workforce logistical issues.
- Establish procedures for deployment of materials over completed geomembranes emphasizing protection of the membrane. Specific discussion shall address deployment of select granular fill on sidewalls.
- Observe where the site survey benchmarks are located, and review methods for maintaining vertical and horizontal control.
- Review permit documentation requirements.
- Review the survey documentation tables and plans that identify the locations where survey documentation information is required.
- Conduct a site walk-around to review material storage locations and general conditions relative to construction.
- Review geomembrane panel and seam layout drawings and numbering systems.
- Establish procedures for use of the geomembrane welding apparatus, if applicable.
- Establish appropriate intervals for seamers to record operating and ambient data.
- Finalize field cutout sample sizes.
- Review liner penetration procedures.
- Review repair procedures.

The meeting will be documented by the CQA officer, and minutes will be distributed to all parties involved in the construction project.

Section 4
General Construction Inspection and Documentation

This section describes general documentation procedures to be implemented including use of forms, identification and resolution of problems or deficiencies, and photographic documentation.

4.1 Daily Reports

A daily summary report shall be prepared by the CQA officer or the RPR under direct supervision of the CQA officer, for each day of activity containing the following information:

1. Date, project name, location, and report preparer's name. Name of RPR on site performing CQA under the supervision of the CQA officer.
2. Time work starts and ends each construction work day. Also, the duration and reason for work stoppages (*i.e.*, weather delay, equipment shortage, labor shortage, unanticipated conditions encountered, *etc.*).
3. Data on weather conditions including temperature, humidity, wind speed and direction, cloud cover, and precipitation.
4. Construction contractor's work force, equipment in use, and materials delivered to or removed from job site.
5. Chronological description of work in progress including locations and type of work performed.
6. Summary of meetings held and attendees.
7. A description of materials used, and references or results of testing and documentation.
8. Discussion of problems/deficiencies identified and corrective actions taken as described in Subsection 4.3 (Problem/Deficiency Identification and Corrective Action).
9. Identification/list of laboratory samples collected, marked, and delivered to laboratories, or clear reference to the document containing such information if samples were obtained.
10. An accurate record of calibrations, recalibrations, or standardizations performed on field testing equipment, including actions taken as a result of recalibrations. In addition, the results of other data recording such as geomembrane seam barrel temperature, or a clear reference to the document containing such information, if applicable.
11. Copies of each RPR's daily field data sheets.

Field data sheets shall be prepared for each workday by each RPR containing the following information:

1. Test or sample location and elevation.
2. Type of inspection.
3. The procedures used.
4. Test data (*i.e.*, proctor value, *etc.*).
5. Results.
6. Personnel involved in the inspection and sampling activities.
7. Signature of the RPR.

4.2 Forms, Checklists, and Data Sheets

Additional forms may be developed during the course of the project to provide specific needs such as geomembrane inspections or simply to improve efficiency of data collection. New forms shall be approved by the CQA officer prior to their use.

4.3 Problem/Deficiency Identification and Corrective Action

Problem or deficiency identification and corrective action will be documented in the daily summary report when a construction material or activity is observed or tested that does not meet the requirements set forth in this plan and in the construction specifications. The summary report should clearly reference other reports, photographs, or forms that contain data or observations leading to the determination of a problem or deficiency. Problem/deficiency identification and corrective action documentation may include the following information:

1. A description of the problem or deficiency, including reference to supplemental data or observations responsible for determining the problem or deficiency.
2. Location of the problem or deficiency, including how and when the problem or deficiency was discovered. In addition, an estimate of how long the problem or deficiency has existed.
3. An opinion as to the probable cause of the problem or deficiency.
4. A recommended corrective action for resolving the problem or deficiency. If the corrective action has already been implemented, then the observations and documentation to show that the problem or deficiency has been resolved. If the problem or deficiency has not been resolved by the end of the day upon which it was discovered, then the report will clearly state that it is an unresolved problem or deficiency. Subsequent daily reports shall indicate the status of problems or deficiencies until resolved.

If the problem or deficiency has not been resolved, the CQA officer and the preparer will discuss the necessary corrective actions. The CQA officer will work with the owner and construction contractor to implement actions as necessary to resolve the problem or deficiency. A description of such problems or deficiencies and corrective actions implemented shall be provided in the construction documentation report.

The CQA officer, working with the owner and construction contractor, will determine if the problem or deficiency is an indication of a situation that might require changes to the plans and specifications and/or the CQA plan. Revisions to the plans or specifications or the CQA plan must be approved by the CQA officer and the site owner after consultation with NC DENR. Documentation of the Department's concurrence and/or conditions regarding proposed changes shall be incorporated into the construction documentation report.

4.4 Photographic Documentation

Photographs will be taken to document observations, problems, deficiencies, corrective actions, and work in progress. Photographs will be in 35-mm print format and will be filed in chronological order in a permanent protective file by the CQA officer, or the RPR.

The following information should be documented in the daily report or a log book for each photograph:

1. Date and time.
2. Location where photograph was taken, including information regarding the orientation of the photograph itself for proper viewing (*i.e.*, looking south).
3. Description of the subject matter.
4. Unique identifying number for reference in other reports.
5. Name and signature of photographer.

4.5 Surveying

Surveying documentation requirements for each liner component are described in their respective plan sections. Required surveying will be performed by a North Carolina registered surveyor experienced in construction surveying. Surveying will be conducted under the supervision of the CQA officer. Surveys will be based on survey control monuments shown on the drawings prepared as part of the construction plan application. Elevations will be based on msl datum, and coordinates will be based on the North Carolina State Plane Coordinate System. The location of field tests and samples will be recorded. Generally, these locations can be determined by reference to nearby construction stakes or markings; however, if such convenient reference is not readily available, the CQA officer or the designated RPR is responsible to provide or request survey control.

Section 5
Compacted Select Clay Fill

Select clay fill refers to the compacted clay in the leachate sump area beneath the composite liner. The select clay fill shall be either bentonite-amended soil or a natural clay that can be compacted to a permeability of 1.0 x 10^{-7} cm/s or less. On-site clay soils are proposed. A clay borrow investigation report will be made available to the contractor. If clay soil from the on-site borrow source is not used, a bentonite-amended soil is proposed.

5.1 Procedures and Observation

The installer will be responsible for means and methods to implement the work. The RPR will observe the compacted clay liner and clay cover construction activities and document relevant observations to support certification of the following requirements:

1. The RPR will confirm the uniformity of the bentonite-amended soil/clay borrow soils. Soil excavation, proportioning, mixing, and placement will be monitored for segregation and removal of unsuitable material and for changes in soil type, color, texture, and moisture content.
2. The construction contractor will segregate and/or remove unsuitable materials such as soils not meeting acceptance criteria (boulders, cobbles, and organic material).
3. The RPR will measure field densities and moisture contents, using methods described in Subsection 5.2 (Sampling Requirements and Acceptance Criteria), to document that the compacted liner is in substantial conformance with the placement specifications and that soil placement has been conducted in a manner to achieve a uniform, homogeneous clay mass.
4. Voids created by nuclear density gauge testing or retrieval of Shelby tube samples will be backfilled with sodium bentonite.
5. The bentonite-amended soil/clay shall be placed in loose lift thicknesses not exceeding 8 inches. Each loose lift shall be compacted with multiple passes using appropriate compaction equipment. If the soil is deposited in thickness exceeding 8 inches, dozers will be used to spread the soil to an 8-inch thickness prior to compaction. This will ensure adequate reduction of clod size and provide a thin layer to achieve required compaction throughout the lift.
6. Areas of unacceptable hydraulic conductivity, compaction density, or moisture content, as defined by Subsection 5.2 (Sampling Requirements and Acceptance Criteria), will be documented by the RPR. Corrective action will consist of moisture conditioning of the soil

or additional compactive effort as necessary. Methods for moisture-conditioning soils are described in Item 7 below. Following corrective actions, such areas will be retested.

7. If necessary, surfaces of liner to receive successive lifts of bentonite-amended soil/clay will be moisture-conditioned either by scarification and addition of water where desiccated, or by disking and air drying where saturated to promote effective bonding of lifts. Following scarification, water will be applied with a spray bar applicator or equivalent methods to achieve uniform distribution.
8. Bentonite-amended soil/clay compaction will be performed in a manner to achieve continuous and complete keying together of soil liner construction areas. Stepped joints will be utilized to connect lateral segments of the soil liner construction.
9. No frozen soils will be used for clay liner construction. Frozen soils in the compaction work area will be removed.
10. Stones that are larger than 0.5 inch in diameter shall be removed from the surface of the final lift of the clay liner to avoid potential for puncturing the geosynthetic clay liner. The method to detect and remove stones requires an initial overfill of compacted clay liner soils approximately 1 inch above designed liner grades. A grader will then blade the liner surface to obtain uniform liner grades and design elevations. Stones present will be exposed and loosened by the grading. The RPR shall inspect the liner during this process and document removal of stones by the contractor. Voids made by removal of stones shall be filled with clay soil, and then the entire liner surface shall be rolled with a smooth drum compactor.
11. Preconstruction planning will be undertaken to sequence construction activities to minimize the length of time any completed clay liner surfaces are exposed prior to receiving protective cover. Protective cover will be provided by installation of the geosynthetic clay liner and the geomembrane.
12. Preconstruction planning will be undertaken to minimize the need for traffic over the completed bentonite-amended soil/clay surface. Heavy trucking of materials (ingress or egress) and cleated equipment will not be allowed directly on completed clay surfaces. If this is unavoidable, an evaluation will be made upon termination of the haul route to determine if the liner should be reconstructed or repaired in such areas. Flotation-type all-terrain vehicles will be used to assist in deployment of the geosynthetic clay liner to avoid disruption of the completed earth liner surface.

5.2 Sampling Requirements and Acceptance Criteria

Field and laboratory sampling frequencies are based on proportionate sampling of construction areas or volume of material placed as specified below. This section describes required analysis, methods, sample frequency, and acceptance limits. Table 5-1 summarizes the minimum QA testing recommended in Subsection 5.3. The RPR will perform field tests and collect soil samples for laboratory analysis.

5.3 Field Testing and Sampling

The following field testing and sampling methods and frequencies will be used by the RPR during construction of the bentonite-amended soil/clay liner and final cover.

- One field density and as-placed moisture content test (ASTM D 3017 and ASTM D 2922 Method B) will be performed for each compacted lift on an approximate 100-foot grid pattern.
- Representative (grab) soil samples of the liner and cover soils will be collected from the initial clay borrow source or from the on-site amended source and submitted to the Soils Testing Laboratory for testing described in Subsection 5.3.4. Additional samples will be collected every 4,000 cy for each major soil type utilized. A sample will also be collected when changes in the physical appearance or soil characteristics are observed.
- A minimum of one undisturbed Shelby tube sample will be obtained for each acre (43,560 ft^2) or less for every lift of bentonite-amended soil/clay placed. A minimum of one test per lift will be performed in each of the leachate sump areas. Samples will be submitted to the Soils Testing Laboratory for testing described in Subsection 5.3.3.
- At a minimum, at least one field density/moisture content test will be conducted per lift and at least one test per day of compacted bentonite-amended soil/clay construction. In confined areas where compaction equipment is hindered or hand compaction is necessary, a minimum of two field density/moisture content tests will be performed for each lift of soil liner placed.

A nuclear density-moisture gauge (NDG) may be used for field moisture and density determination. The calibration of NDGs used for documentation shall be initially checked and adjusted (if necessary) according to the manufacturer’s guidelines. Initial calibration shall be made with a one of the alternate test methods identified in the construction specifications for field density and moisture content.

5.3.1 Field Testing Acceptance Criteria

Acceptance criteria for field density will require soil compaction to a minimum of 95 percent of the Standard Proctor (ASTM D 698) maximum dry density. Specific moisture content requirements will be identified in the construction specifications. The acceptable range will be based on Proctor moisture-density relationships and compaction versus permeability relationships.

5.3.2 Laboratory Testing

Routine laboratory testing of the compacted liner soils will be performed on samples from the clay borrow area or samples from the disking operation and on the in-place soils collected by the RPR. Samples for determining in-place properties will be collected by pushing Shelby tubes. Soil characteristics will be determined from representative samples and from Shelby tube samples.

5.3.3 Undisturbed Sample Analysis

The following analysis will be performed on ***all*** undisturbed samples obtained:

PARAMETER	TEST METHOD
Hydraulic Conductivity	ASTM D 5084 or SW 846-USEPA Method 9100
Moisture Content and Dry Density	ASTM D 2216
Atterberg Limits	ASTM D 4318
Grain-size Analysis (P200)	ASTM D 422 (1)

(1) Percentage of soil finer than the No. 200 sieve (*i.e.*, soil finer than 0.075 mm).

5.3.4 Representative Sample Analysis

The following laboratory analyses will be performed on ***all*** representative samples obtained, except where noted:

PARAMETER	TEST METHOD
Moisture-Density Relationship using Standard Proctor Compaction	ASTM D 698 (1, 2)
Atterberg Limits	ASTM D 4318
Grain-size Analysis (sieve and hydrometer)	ASTM D 422 (3)
Moisture Content	ASTM D 2216
Hydraulic Conductivity (4)	ASTM D 5084 or SW 846-USEPA Method 9100

(1) A five-point Proctor analysis is required for first and second sampling criteria.
(2) A one-point Proctor analysis may be utilized for representative samples collected for the third sampling criteria (apparent changes in soil quality) to verify applicability of previously analyzed moisture-density relationships. If the result does not verify applicability, a five-point analysis will be performed in accordance with the first sampling criteria.
(3) Distribution shall be reported through the 0.002-mm particle size.
(4) For every 8,000 cy of soil extracted from the borrow source, perform one set of hydraulic conductivity tests. A set typically consists of four hydraulic conductivity tests run on a sample of soil remolded to four different moistures and dry densities.

5.3.5 Laboratory Testing Acceptance Criteria

1. A saturated hydraulic conductivity of 1×10^{-7} cm/s or less

5.3.6 Typical Index Properties Recommended for Achieving Hydraulic Conductivities of $1x10^{-7}$ cm/s or Less

1. A liquid limit of 30 percent or greater
2. A plasticity index of 15 percent or greater
3. A percentage of fines (*i.e.*, material finer than the No. 200 sieve or 0.075 mm) 60 percent or greater.
4. A percentage of clay (*i.e.*, material finer than 0.002 mm) 20 percent or greater.

5.4 Thickness Documentation

The top of clay liner grades will be surveyed at a minimum on the same 50-foot grid pattern, as other locations surveyed for subbase grades. Clay thickness at slope breaks will be surveyed. The clay liner thickness will be determined at surveyed locations and reported in table fashion. The minimum acceptable bentonite-amended soil/select clay liner thickness will be 2-foot vertical to the bottom or to the slope. The location and elevation of samples requiring surveying will be recorded.

Table 5-1
Summary of Quality Assurance Testing for the Select Clay/Bentonite-Amended Soil Liner

TEST	FREQUENCY	COMMENT
Atterberg Limits Test [ASTM D 4318]	One every 4,000 cy and material changes	Source material: clay/bentonite-amended soil
Grain-size analyses (sieve and hydrometer) [ASTM D 422]	One every 4,000 cy and material changes	Source material: clay/bentonite-amended soil
Moisture Content [ASTM D 2216]	One every 4,000 cy and material changes	Source material: clay/bentonite-amended soil
Density/Moisture (Standard Proctor) [ASTM D 698]	One every 4,000 cy and material changes	Source material: clay/bentonite-amended soil
Permability Testing (Falling Head) [ASTM D 5084 or SW846-USEPA Method 9100]	Four tests on one sample obtained every 8,000 cy and material changes	Source material: clay/bentonite-amended soil (on remolded source material)
Proofroll	All surfaces prior to liner placement	Subgrades for liner construction
Density/Moisture Content [ASTM D 2922 and ASTM D 3017] or [ASTM D 1556] or [ASTM D 2937]	One per 10,000 ft^2 per lift (approximate 100-foot grid pattern)	Liner: clay/bentonite-amended soil
Permability Testing (Falling Head) [ASTM D 5084 or SW 846-USEPA Method 9110]	One per acre (43,560 ft^2) per lift	Source material: clay/bentonite-amended soil (on tube samples obtained from the *in situ* liner)
Atterberg Limits Test [ASTM D 4318]	One per acre (43,560 ft^2) per lift	Source material: clay/bentonite-amended soil (on tube samples obtained from the *in situ* liner)
Grain-Size Analyses (P200) [ASTM D 422]	One per acre (43,560 ft^2) per lift	Source material: clay/bentonite-amended soil (on tube samples obtained from the *in situ* liner)
Density/Moisture [ASTM D 2216]	One per acre (43,560 ft^2) per lift	Source material: clay/bentonite-amended soil (on tube samples obtained from the *in situ* liner and subgrade)

Section 6
Granular Materials

Granular materials include "granular fill," "aggregate fill," and other granular materials shown or specified for pipe bedding and backfill material. The granular fill will function as the filtration layer between the protection layer of select waste (ash) and the aggregate fill. The aggregate fill will function as the leachate collection layer above the liner. It will be located between the geosynthetic protection layer and the granular fill layer. The granular fill covers the aggregate fill drainage layer and acts as a filtration layer. Granular materials refers to pipe-bedded material to be used for structural support of leachate collection pipes. Limestone and dolomite stone shall not be used in the leachate collection system unless no other suitable material is reasonably available. The aggregate fill should be rounded to subangular.

Refer to details on the drawings prepared as part of the construction plan application for specific details regarding the leachate drainage blanket and leachate collection pipe trench.

6.1 Procedures and Observation

The RPR will observe granular material placement activities and document relevant observations to support certification of the following requirements:

1. The RPR shall periodically observe aggregate fill material used for pipe bedding material, and granular fill for general conformance to material specifications and may randomly sample loads. The RPR will perform routine conformance sampling as defined in Subsection 6.2.
2. No trucks or heavy equipment shall travel directly on the geomembrane. Only low-contact-pressure equipment may operate over the geomembrane when there is a minimum 8-inch-thick layer of granular material in-place. Procedures for deployment of pipe, aggregate fill, and/or geotextiles overlying geomembranes will be planned at the preconstruction meeting. Special requirements for geomembrane protection and equipment necessary to deploy materials must be approved by the CQA officer.
3. Care shall be exercised during placement of pipe bedding material to prevent undue damage to pipes, geomembrane, and geotextiles. Stone shall not be dropped from a height greater than 3 feet above the bottom of the pipe trench.
4. A geotextile cushion (Geocushion™) or geocomposite shall be placed between the geomembrane and the leachate collection/pipe bedding material.

5. A minimum of 3 inches of bedding material shall be placed under leachate collection pipes prior to pipe placement, and a minimum of 6 inches of bedding material shall be placed over the top of leachate collection pipes.
6. A minimum 14-inch-thick granular material shall be placed between the top of the composite liner and the layer of select waste (ash).
7. If granular fill is stockpiled on site prior to use, measures should be taken to minimize contamination by fines such as wind-blown particles and surface soils during loading operations.

6.2 Sampling Requirements and Acceptance Criteria

Field sampling and laboratory testing frequencies are based on proportionate sampling of construction areas or volume of material placed as specified below. This section describes the required analysis, methods, sampling frequency, and acceptance limits. The RPR will collect granular material samples for laboratory analysis.

6.2.1 Field Testing

No field testing will be required for pipe bedding material or granular fill. However, as stated in Subsection 6.1 above, the RPR will perform visual inspection of these materials for conformance to material specifications and may randomly sample deliveries.

6.2.2 Laboratory Testing

Representative (grab) samples will be obtained from the proposed bedding material, and graded granular fill sources prior to delivery of the material. The source sampling frequency will be dependent on the apparent uniformity of the source and must be approved by the CQA officer.

Grab samples of pipe bedding material, and graded fill soils placed will be collected and analyzed as follows:

SOIL TYPE	FREQUENCY	PARAMETER	TEST METHOD
Granular fill	1/1,000 CY (1, 2)	Grain-size	ASTM D 422 (3)
Granular fill	1/2,500 CY (2, 4)	Remolded hydraulic conductivity	ASTM D 2434
Pipe bedding material	1/1,000 L.F. of trench (5)	Grain-size	ASTM D 422 (3)
Pipe bedding material	1/2,000 L.F. of trench	Remolded hydraulic conductivity	ASTM D 2434

(1) For lesser volumes, a minimum of four samples shall be tested.
(2) This frequency may be reduced for uniform sources. Proposed reductions will be submitted for NC DENR approval prior to implementation.
(3) Testing shall be required only to the #200 sieve.
(4) For lesser volumes, a minimum of two samples shall be tested.
(5) For documentation areas with less than 3,000 feet of pipe trench, a minimum of three samples shall be tested.

Laboratory Testing Acceptance Criteria

Pipe bedding material shall have a uniformity coefficient less than 4, contain no more than 5 percent by weight passing the #4 sieve, have a maximum particle diameter of ¾ inch, have a remolded hydraulic conductivity of 1 cm/s or greater, and have a rounded to subangular particle shape. Granular fill materials shall meet the grain-size distribution criteria specified in the construction plans and specifications.

6.3 Thickness Documentation

Granular fill in the leachate collection layer, and placed along collection pipe alignments will be surveyed for elevation. Granular materials in the leachate drainage blanket will be surveyed on a 50-foot grid. Pipe bedding material will also be surveyed prior to pipe placement and following pipe backfilling at 50-foot intervals to document the thickness of aggregate fill placed below pipe inverts and above the top of pipe. The minimum acceptable stone thickness will be 3 inches below and 6 inches above the leachate collection piping.

Section 7
Geotextiles and Geocushion™

This section of the CQA plan applies to non-woven geotextiles used for soil separation/ filtration in roadways and riprap channels, and for protection of the geomembrane. The geotextiles used in the geocomposites will meet the applicable requirements of this section. Geocomposites are discussed in Section 11. A Geocushion™ or geocomposite will be placed over the geomembrane liner. The Geocushion™ will meet the applicable requirements of this section.

This section is divided into three major subheadings, which cover the QA requirements for pre-installation (includes geotextile manufacturers), installation, and post-installation (includes the final examination of the geotextiles prior to placing the appropriate material above the geotextile). The terms pre-installation, installation, and post-installation are applicable only to the geotextile installation and do not apply to the overall construction of the landfill facility.

7.1 Pre-Installation

7.1.1 Manufacturing

Material Specifications

The geotextile or Geocushion™ will be supplied to the site in factory rolls.

Quality Control Requirements

Prior to the delivery of any geotextile or Geocushion™ rolls to the site, the geotextile or Geocushion™ manufacturer will provide to the CQA officer the manufacturer's QC plan used for production of the geotextile rolls.

Every roll of geotextile for delivery to the site must be manufactured and inspected by the geotextile or Geocushion™ manufacturer, according to the following requirements:

1. The geotextile or Geocushion™ must contain no needles used for punching.
2. The geotextile or Geocushion™ must be free of holes and any other sign of contamination by foreign matter.

Manufacturer's Certification

The geotextile manufacturer will provide certification, based on tests performed in accordance with the methods listed in Table 7-1, that the geotextile supplied under this plan will meet the material specifications listed in Table 7-3. The Geocushion™ manufacturer will provide certification based on tests performed in accordance with the methods and frequency listed in Table 7-2 that the Geocushion™ supplied under this plan will meet the material specifications listed in Table 7-4. These tests may be performed by the geotextile or Geocushion™ manufacturer's laboratory or a laboratory contracted by the manufacturer. Additionally, the manufacturer shall provide certification that the manufacturer's QC plan was fully implemented for the geotextile or Geocushion™ materials supplied under this plan. The manufacturer shall provide documentation to verify the results of the manufacturer's QC plan implementation if required by the CQA officer.

7.1.2 Delivery, Handling, and Storage of Geotextile and Geocushion™ Rolls

(Note: ASTM Standard D4873 titled *Standard Guide for Identification, Storage and Handling of geotextiles* was used in preparing these guidelines.)

Each geotextile or Geocushion™ roll, for use at the landfill facility, will be marked by the geotextile or Geocushion™ manufacturer with the following information and in the following manner:

1. When fabric is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
2. Each roll label will contain the following information at a minimum:
    - Name of manufacturer (or supplier)
    - Style and type number
    - Unit weight (ounces per square yard)
    - Roll length and width
    - Batch (or lot) number
    - Nominal product thickness
    - Date of manufacture
    - Direction for unrolling
    - Roll number

3. On the outside of the wrapping, all lettering should be a minimum ½ inch high, and on the inside of the core, the lettering should be at least ¼ inch high.

The geotextile or Geocushion™ manufacturer will use the following guidelines in packaging, wrapping, and preparing all geotextile rolls for shipment:

1. When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
2. Cover each roll with a wrapping material that will protect the geotextile from damage due to shipment, water, sunlight, or contaminants.

The following practices should be used as a minimum in receiving and storing geotextile rolls in the designated storage area at the job site:

1. While unloading or transferring the geotextile rolls from one location to another, prevent damage to the wrapping or to the geotextile itself. If practicable, the installer may use forklift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least two thirds the length of the rolls to avoid breaking the cores and possibly damaging the geotextile. Do not drag rolls.
2. Store the geotextile rolls to ensure that they are adequately protected from the following:
    - Precipitation
    - Ultraviolet radiation, including sunlight
    - Strong oxidizing chemicals, acids, or bases
    - Flames, including welding sparks
    - Temperatures in excess of 160°F
    - Soiling

The RPR will observe and document, throughout the pre-installation, installation, and post-installation periods, that the installer provides adequate handling equipment used for moving geotextile or Geocushion™ rolls and the equipment and that the handling methods used do not pose unnecessary risk of damage. The installer is responsible for means and methods to implement the work.

The installer will be responsible for ensuring that all materials installed meet specifications (*i.e.*, the roll marking label information indicates required specifications and properly represents materials). The RPR will maintain a log of geotextile or Geocushion™ roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job site:

1. Date of shipment from geotextile or Geocushion™ manufacturer
2. Date of receipt of delivery at job site
3. For each geotextile roll, the following information will be noted:
   - Roll number
   - Batch (lot) number

7.2 Installation

This section describes the QA requirements applicable to the installation of geotextiles. This section describes installation, observation, and documentation of geotextiles or Geocushion™.

7.2.1 Placement

The installer will install all geotextiles or Geocushion™ in such a manner to ensure that they are not damaged and in a manner that complies with the following:

1. On sideslopes, the geotextiles will be securely anchored and then rolled down the slope in such a manner as to continually keep the geotextile or Geocushion™ in tension.
2. In the presence of winds, all geotextiles or Geocushion™ will be secured by other suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
3. In-place geotextiles or Geocushion™ will be cut with special care to protect other materials from damage that could be caused by the cutting of the geotextiles.
4. The installer will take necessary precautions to prevent damage to any underlying layers during placement of the geotextile or Geocushion™ .
5. During placement of geotextiles, care will be taken not to entrap in the geotextile or Geocushion™ any stones, excessive dust, or moisture that could damage the geotextile or Geocushion™, or generate clogging of drains or filters.
6. A visual examination of the geotextile or Geocushion™ will be carried out over the entire surface after installation by the installer to ensure that no potentially harmful foreign objects, such as needles, are present.

7.2.2 Seams and Overlaps

The Geocushion™ manufacturer's requirements for seaming and overlapping of Geocushion™ rolls will be met. The following requirements will be met with regard to seaming and overlapping of geotextile rolls:

1. A minimum 12-inch fabric overlap will be required to form geotextile seams.

2. No horizontal seams will be allowed on slopes steeper than 10-horizontal to 1-vertical (*i.e.*, seams will be along, not across, the slope), except as part of a geotextile repair. Horizontal repair seams on such slopes will be sewn or thermally bonded.
3. The installer will pay particular attention to seams to ensure that no earthen materials could be inadvertently trapped beneath the geotextile.
4. Sewing (if required per item 2 above) will be performed with thread made from the same base material as the geotextile, or suitable equivalent.

The RPR will be responsible for observing and documenting that the above provisions are performed by the installer in an acceptable manner.

7.3 Post-Installation

7.3.1 Final Examination

The RPR will perform a final geotextile or Geocushion™ examination after installation of each geotextile or Geocushion™ layer has been completed. The objectives of the final examination are as follows:

1. Examine for presence of holes, tears, or other deterioration.
2. Examine geotextile or Geocushion™ for excessive tension due to stretching of the fabric during installation.

If there will be an extended time delay between completion of the geotextile or Geocushion™ and the start of the installation of any overlying cover, then the installer will make provisions, by temporarily covering or using other suitable methods, to protect the geotextile against exposure to sunlight and ultraviolet radiation.

7.3.2 Placement of Soil or Granular Materials

The construction contractor will place all soil or granular materials located on top of a geotextile or Geocushion™ in such a manner as to minimize the following:

1. Damage of the geotextile or Geocushion™
2. Slippage of the geotextile or Geocushion™ on underlying layers
3. Excessive tensile stresses imposed on the geotextile or Geocushion™

Table 7-1
Geotextile Tests and Test Methods

PROPERTY	TEST METHODS	MINIMUM FREQUENCY OF TESTING
Apparent Opening Size	ASTM D 4751	1 per 100,000 ft^2
Grab Tensile Properties Tensile Strength Break Elongation	ASTM D 4632	1 per 100,000 ft^2
Mass Per Unit Area	ASTM D 5261	1 per 100,000 ft^2
Permitivity	ASTM D 4491	1 per 100,000 ft^2
Puncture Resistance	ASTM D 4833	1 per 100,000 ft^2
Trapezoidal Tear	ASTM D 4533	1 per 100,000 ft^2
Burst Strength	ASTM D 3786	1 per 100,000 ft^2

Table 7-2
Geocushion™ Tests and Test Methods

PROPERTY	TEST METHODS	MINIMUM FREQUENCY OF TESTING
Mass Per Unit Area	ASTM D 5261	1 per 100,000 ft^2
Thickness	ASTM D 1777	1 per 100,000 ft^2
Tapered Pin Puncture	FTM 101C-M2065	1 per 100,000 ft^2
Truncated Cone Puncture	GRI-GM3 2 inch (50 mm) cone height	1 per 100,000 ft^2

Table 7-3
Geotextile Acceptance Specifications

TEST	TYPE A UNDER RIPRAP AND FINAL COVER GEOCOMPOSITE	TYPE B USED UNDER ROADWAYS	TYPE C BOTTOM OF LEACHATE COLLECTION LAYER GEOCOMPOSITE	CRITERION
Apparent Opening Size (US Sieve Number)	70	70-100	100-140	Maximum
Grab Tensile Properties (1) Tensile Strength (lbs)	200	200	300	Minimum
Grab Tensile Properties (1) Break Elongation (%)	50	50	50	Minimum
Permitivity (1/sec)	1.2	1.2	1.0	Minimum
Puncture Resistance (lbs)	80	80	175	Minimum
Mullen Burst (psi)	400	360	580	Minimum
Trapezoidal Tear (lb)	65	65	115	Minimum

(1) These tests will be performed and results will be reported in both the machine and cross directions.

Table 7-4
Geocushion™ Acceptance Specifications

TEST	GEOCUSHION™ 32R	CRITERION
Mass/Area	32 oz/yd^2 (1,080 g/m^2)	Minimum
Thickness	0.3 in. (7.5 mm)	Minimum
Tapered Pin Puncture	400 lb. (1,780 N)	Minimum
Truncated Cone Puncture	32 psi (220 kPa)	Minimum

Section 8
Geomembranes

This section of the CQA plan applies to the HDPE geomembrane used in the landfill base composite liner and the VFPE geomembrane used in the cap composite liner.

The geomembrane will be supplied to the site in factory rolls. ***No factory seams will be used to prepare larger panels of geomembrane for delivery to the site***. This plan, therefore, does not contain any QA/QC requirements for factory seaming.

This section is divided into four major subheadings, which cover the QA requirements for the pre-installation (includes resin manufacturers and geomembrane manufacturers), installation, field seaming, and post-installation (includes the final examination of the geomembranes prior to placing the appropriate material above the geomembrane). These terms pre-installation, installation, field seaming, and post-installation are applicable only to the geomembrane installation and do not apply to the overall construction of the landfill facility.

8.1 Pre-Installation

This section describes the QC measures that are applicable to the polyethylene (PE) resin manufacturers, geomembrane manufacturers, and finished geomembrane roll delivery to the site prior to installation.

The geomembranes must be fabricated from polyethylene resin, and the fabricated HDPE geomembrane must be classified as Type III, Class C, Category 4 or 5 as defined by ASTM D 1248. The fabricated VFPE membrane must be classified as Type III, Class C, Category 3 or 4 per ASTM D 1248. (Note: the classifications are based on tests performed on the finished product, ***not*** the polyethylene resin used to fabricate the geomembrane.)

In the event that during the course of construction, geomembrane materials are obtained from a different manufacturer or are made from different resins, seam samples formed by joining the original and the proposed geomembrane shall be tested to confirm the construction compatibility of the two geomembrane materials. Prior to the use of the new geomembrane material, a minimum of two seamed samples (as described above) shall be submitted to the geosynthetics laboratory for nondestructive and destructive seam testing as described in Subsections 8.3.4 and 8.3.5. The CQA officer shall review the testing results prior to authorizing the use of the new geomembrane material.

8.1.1 Manufacturing

Material Specifications

The following list specifies the required membrane materials for liner construction:

LINER	MEMBRANE MATERIALS
Base liner	60-mil HDPE (textured on slide slopes)
Final cover side slopes and cap	40-mil VFPE-textured

Quality Control Requirements

Prior to the delivery of any geomembrane rolls to the site, the geomembrane manufacturer will provide the CQA officer with the following information:

1. The resin supplier, location of supplier's production plant(s), and resin brand name and product number.
2. Any test results conducted by the geomembrane manufacturer and/or the resin manufacturer testing laboratories to document the quality of the resin used in fabricating the geomembrane.
3. The QC plan that the geomembrane manufacturer will be using for the geomembrane being supplied.

Every roll of geomembrane for delivery to the site must be manufactured and inspected by the geomembrane manufacturer according to the following requirements:

1. First quality polyethylene resin must be used.
2. The geomembrane must contain no more than a maximum of 1 percent by weight of additives, fillers, or extenders, excluding carbon black.
3. The geomembrane must have no striations, roughness (except for where the textured geomembrane is specified), or bubbles on the surface.
4. The geomembrane must be free of holes, blisters, undispersed raw materials, or any other sign of contamination by foreign matter.

The geomembrane manufacturer will routinely perform the following test program on the raw resin and will report the results on a periodic basis to the CQA officer:

1. Collect and test a minimum of one sample for the parameters in Item #2 below for every 50,000 pounds of resin received.

2. Perform carbon black content and carbon black dispersion. These test methods are listed in Table 8-2.

Manufacturer's Certification

The geomembrane manufacturer will provide certification, based on tests performed by either the geomembrane manufacturer's laboratory or other outside laboratory contracted by the geomembrane manufacturer, that the geomembrane supplied under this plan will meet the specifications of GRI-GM13 Standards, Table 1a and Table 2a. Additionally, the manufacturer shall provide certification that the manufacturer's QC plan was fully implemented for the geomembrane material supplied under this plan. The manufacturer shall provide documentation to verify results of the manufacturer's QC plan implementation if requested by the CQA officer.

8.1.2 Delivery, Handling, and Storage of Geomembrane Rolls

The geomembrane will be protected during shipment from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. The geomembrane rolls will be stored on the site in a designated area and will be protected from long-term ultraviolet exposure prior to actual installation.

Each geomembrane roll will be marked by the geomembrane manufacturer with the following information (on a durable gummed label, or equivalent, on the inside of the core):

1. Name of manufacturer
2. Product type and identification number (if any)
3. Roll length and width
4. Batch (or lot) number
5. Nominal product thickness
6. Date of manufacture
7. Roll (or field panel) number

When cores are required for preparing geomembranes for shipment, the manufacturer shall use cores with sufficient crushing strength to avoid collapse or other damage while in use.

The following practices should be used as a minimum in receiving and storing geomembrane rolls in the designated storage area at the job site:

1. While unloading or transferring the geomembrane rolls from one location to another, prevent damage to the geomembrane itself. The preferred method involves use of a spreader-bar, straps, and a loader. Do not drag rolls.
2. Store the geomembrane rolls to ensure that they are adequately protected from the following:
    - Equipment damage
    - Strong oxidizing chemicals, acids, or bases
    - Flames including welding sparks
    - Temperatures in excess of 160°F
    - Soiling

The RPR will observe and document, throughout the pre-installation, installation, and post-installation periods that the installer provides adequate handling equipment for moving geomembrane rolls and that the equipment and the handling methods used do not pose unnecessary risk of damage. The installer is responsible for means and methods to implement the work.

The installer will be responsible for ensuring that all materials installed meet specifications (*i.e.*, that the roll marking label information indicates required specifications and properly represents materials). The RPR will maintain a log of geomembrane roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job site:

1. Date of shipment from geomembrane manufacturer
2. Date of receipt of delivery at job site
3. For each geomembrane roll, the following information will be noted:
    - Roll number
    - Batch (lot) number

8.2 Installation

This subsection includes discussions of geomembrane roll testing requirements, earthwork required for geomembrane placement, placement of the geomembrane, defects and repairs of geomembranes, and requirements applicable to other materials in contact with the geomembranes. Subsection 8.3 describes the installation and testing requirements for geomembrane seams.

All parties involved in the installation of the geomembrane should be familiar with geomembranes and should emphasize protection of the geomembrane from damage during construction activities.

8.2.1 Testing Requirements

This subsection describes the test methods, including sampling procedures and frequencies, and the role of the Geosynthetic Testing Laboratory in testing the geomembrane roll samples. Subsection 8.1.1, under QC requirements, describes the test methods that are performed on an infrequent basis to demonstrate the uniformity of resin used to fabricate geomembranes shipped to the job site. Seam testing is described in Subsections 8.3.4 and 8.3.5.

Test Methods

Geomembrane roll samples will be collected by the RPR. Sample frequency will be based on ASTM D 4354 procedure A where the number of units per lot is defined as the number of rolls for a specified lot (using batch or lot numbers) delivered to the job site in one shipment or one test per 100,000 square yards of material delivered to the site, whichever is less. Required sampling frequencies are shown in Table 8-1.

Samples will be 3 feet long by the full width of the roll and will not include the first 3 feet of any roll. Since machine direction for geomembrane rolls is the direction that the material comes off the roll, machine direction for any sample will always be along the 3-foot-length dimension of the sample.

Table 8-2 and Table 8-3 list the tests and the test methods to be performed on the HDPE and VFPE geomembrane roll samples, respectively. The specifications and methods used in evaluating the results are discussed below under procedures for determining geomembrane roll test failures. Unless specified otherwise, preparation of sample specimens will be performed in accordance with the referenced test method. Results for tear resistance and each of the tensile property tests will be reported for both the machine and cross direction.

Role of Testing Laboratory

The Geosynthetic Testing Laboratory will be responsible for performing the tests on samples submitted to them as described above under test methods. Results of tests performed will be reported to the CQA officer and the RPR.

Retesting of geomembrane rolls for QA purposes, because of failure to meet any or all of the acceptance specifications listed in Table 8-2 and Table 8-3, can only be authorized by the CQA officer.

The geomembrane manufacturer and/or installer may perform their own tests according to the methods and procedures defined in Table 8-2 and Table 8-3; however, the results will only be applicable to their own QC needs. These results will not be substituted for the QA testing described herein.

Procedures for Determining Geomembrane Roll Test Failures

Table 8-4 and Table 8-5 list the acceptance specifications for the HDPE and VFPE geomembranes, respectively. These tables apply to both textured and nontextured geomembranes. For those tests where results are reported for both machine and cross direction, each result will be compared to the listed specification to determine acceptance.

The HDPE membrane values listed in the acceptance specifications of Table 8-4 are from Table 1a and Table 2a of the GRI-GM13 standards. Currently, no industry-accepted standard specifications exist for textured geomembranes. Therefore, textured HDPE geomembranes will be required to meet the same specifications listed for nontextured geomembranes in Table 8-4.

The acceptance values for VFPE listed in Table 8-5 are based on current acceptable industry practice and manufacturer's minimum specifications for textured VFPE geomembranes.

The following procedure will be used for interpreting results:

1. If the test values meet the stated specifications in Table 8-4 and Table 8-5, then the roll and the lot will be accepted for use at the job site. If the sample represents all rolls from an entire shipment, then the entire shipment will also be considered accepted.
2. If the results do not meet the specifications, then the roll, the lot, and the entire shipment, if applicable, will be considered unsuitable for use in the liners at the site. The geomembrane manufacturer can request, however,

retesting of samples from either the original roll sample or another sample collected by the RPR and forwarded to the Geosynthetic Testing Laboratory. For retesting, ***two*** additional tests must be performed for the failed test procedure. If both of the retests are acceptable, then the roll and lot will be considered acceptable; if either of the two additional tests fail, then the roll and lot are unsuitable without further recourse and will be immediately marked for removal from the site.

8.2.2 Earthwork

The construction contractor will be responsible for preparing the supporting soil according to the plans and specifications and Section 5 and Section 14 of this plan. For installation of any of the geomembranes, the installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. This certification of acceptance will be reported by the installer prior to the start of geomembrane installation in the area under consideration. Unacceptable areas noted by the installer will be immediately reported to the RPR.

The soil surface will also be examined by the RPR to evaluate any areas softened by precipitation or cracked due to desiccation. The daily observation will be documented in the daily report. Areas determined to be unacceptable will be reworked by the construction contractor until acceptable.

8.2.3 Placement

Location and Layout Drawing

A layout drawing for the geomembrane installation covered by this plan will be prepared by the installer prior to installation and submitted to the CQA officer, showing the location of geomembrane panels to be installed. Geomembrane panels will be identified by the RPR by the corresponding geomembrane roll number on the layout drawing as they are installed.

Installation Techniques

Geomembrane panels will be installed using one of the techniques described below. The installer will determine the method that best suits the conditions at the time of installation considering factors such as schedule and weather conditions.

1. All geomembrane panels are placed prior to field seaming, in order to protect the underlying soil from rain, *etc.* Seams may be tack-welded or

sand-bagged to prevent the geomembrane panels from shifting and to maintain proper overlap for eventual seaming.

2. Geomembrane rolls are placed one at a time, and each panel is seamed immediately after placement.
3. Any combination of the above two techniques.

If a decision is reached to place all panels prior to field seaming, care should be taken to facilitate drainage in the event of precipitation. Scheduling decisions must be made during placement in accordance with varying conditions. The RPR will evaluate changes in the schedule if proposed by the installer and will advise the CQA officer on the acceptability of the changes. The RPR will document that the condition of the supporting soil has not changed detrimentally during installation.

The RPR will record the roll number, location, and date of each geomembrane panel installed.

The installer shall take the following precautions while installing the geomembrane:

1. Equipment used does not damage the geomembrane by handling, excessive heat, leakage of hydrocarbons, or by other means.
2. Personnel working on the geomembrane do not smoke, wear damaging clothing, or engage in other activities that could damage the geomembrane.
3. Method used to unroll the geomembrane does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.
4. Method used to place the rolls minimizes wrinkles (especially differential wrinkles between adjacent panels).
5. Adequate temporary loading or anchoring (continuously placed, if necessary), which will not damage the geomembrane, will be placed to prevent uplift by the wind.
6. Direct contact with the geomembrane will be minimized. The geomembrane will be protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

Weather Conditions

Geomembrane placement will not be performed in an area of ponded water, during precipitation events, or in the presence of excessive winds. The RPR will document that this condition is fulfilled. The CQA officer will cause to cease or postpone the geomembrane placement when conditions are unacceptable.

Damages

The RPR will examine each panel for damage after placement and determine which panels, or panel portions, should be rejected, repaired, or accepted. Damaged panels or panel portions that have been rejected will be marked, and their removal from the site will be recorded by the RPR. Panel repairs will be made according to the procedures described in Subsection 8.2.4.

8.2.4 Defects and Repairs

This section applies to all defects and repairs resulting from examinations, tests, or visual observations performed on the geomembrane material itself and on the seams used in joining rolls in the field.

Identification

All seam and non-seam areas of the geomembranes will be examined and documented by the RPR for identification of defects, holes, blisters, undispersed raw materials, and any signs of contamination by any foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The smooth nonconductive geomembrane surface will be swept with a broom and/or washed by the installer if the amount of dust or mud inhibits examination. The textured conductive backed HDPE will be spark tested in accordance with technical specifications and manufacturer's recommended procedure. Spark testing will be performed in addition to destructive and nondestructive seam testing.

Evaluation

Each suspect area identified will be nondestructively tested using the vacuum box test method described in Subsection 8.3.4. Each location that fails the nondestructive tests will be marked by the RPR and repaired by the installer.

Repair Procedures

Any portion of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test will be repaired. Several procedures exist for the repair of these areas. The procedures available include the following:

1. Patching—used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
2. Grinding and rewelding—used to repair small sections of extruded seams.
3. Spot welding or seaming—used to repair small tears, pinholes, or other minor, localized flaws.
4. Capping—used to repair large lengths of failed seams.
5. Topping—used to repair areas of inadequate seams that have an exposed edge.
6. Removing the bad seam and replacing with a strip of new material welded into place—used for repairing large lengths of fusion seams.
7. Others may be used at the recommendation of the installer if agreed upon by the CQA officer and the RPR.

The repair procedures, materials, and techniques will be approved in advance of the specific repair by the CQA officer, RPR, and installer. At a minimum, the following provisions will be satisfied:

1. Patches or caps will extend at least 6 inches beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 inches.
2. The geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.

Examination of Repairs

Each repair will be numbered and logged by the RPR. Each repair will be nondestructively tested according to Subsection 8.3.4. Repairs that pass the above testing will be considered to be adequately repaired, except that large caps may be of sufficient extent to require destructive seam sampling and testing, at the discretion of the RPR, according to the provisions of Subsection 8.3.5.

Failed tests indicate that the repair was inadequate and will be redone and retested until a passing result is obtained. The RPR will document that all repairs have been subjected to nondestructive testing and will record the number of each repair, the date, and the test outcome.

Large Wrinkles

When seaming of the geomembrane is completed, the RPR will examine the geomembrane for wrinkles and determine which wrinkles should be cut and seamed by the installer. The wrinkle repair will be done in accordance with the equipment and procedures described in Subsections 8.3.2 and 8.3.3 (General Seaming Procedures), respectively, and it will be nondestructively tested using the vacuum box test method described in Section 8.3.4.

8.3 Field Seaming

This section covers the QA procedures on seams used to join the rolls of geomembrane into a continuous layer. The installation of each of the geomembranes at the landfill facility will include 100 percent nondestructive testing of all field seams for joining adjacent rolls of geomembranes to determine openings or gaps between geomembrane sheets. In addition, destructive testing will be performed at a routine interval for determining the strength and mode of failure of field seams in both the shear and peel modes.

The allowable field seam methods, equipment, personnel qualifications, and destructive and nondestructive testing methods are described in this section.

8.3.1 Seam Layout

The installer will provide the CQA officer and the RPR with seam layout drawings for each of the geomembrane installations covered by this plan showing each expected seam. The CQA officer will review the seam layout drawing and document that it is consistent with accepted practice and the design plans and specifications.

No horizontal seams will be allowed on slopes greater than 5- horizontal to 1- vertical. In corners and at other odd-shaped geometric intersections, the number of seams should be minimized. A seam numbering system comparable and compatible with the geomembrane roll numbering system will be agreed upon at the preconstruction meeting.

8.3.2 Seaming Equipment

The approved process for production field seaming (roll to roll) are the dual hot wedge (fusion-type) seam method and the extrusion fillet weld process. Specialty seams and repair seams (non-production) will be done by the extrusion fillet weld process. No other processes can be used without prior written authorization from the CQA officer and the RPR. Only equipment that has been specifically approved by make and model will be used.

Dual Hot Wedge Process

The installer will meet the following requirements regarding the use, availability, and cleaning of the equipment to be used at the job site:

1. An automated self-propelled type of apparatus will be used.
2. The welding apparatus will be equipped to continuously monitor applicable temperatures.
3. One spare operable seaming device will be maintained on site at all times.
4. Equipment used for seaming should not damage the geomembrane.
5. The geomembrane should be protected in areas of heavy traffic to prevent damage as discussed in Subsection 8.2.3.
6. For cross seams, the edge of the cross seams will be ground to a smooth incline (top and bottom) prior to welding.
7. For cross seams, the intersecting dual hot wedge seam must be patched using the extrusion fillet process described below.
8. The electric generator for the equipment will be placed on a smooth base in such a way that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric will be placed beneath the hot equipment after usage.

The installer will keep records for each seamer performing dual hot wedge seaming, including welding machine I.D. number, ambient air temperature, geomembrane surface temperature, and machine operating pressures and temperatures. This data will be recorded at intervals as agreed to at the preconstruction meeting.

Extrusion Fillet Process

The installer will meet the following requirements regarding the use, availability, and cleaning of extrusion welding equipment to be used at the job site:

1. The welding apparatus will be equipped to continuously monitor temperature at the nozzle.
2. One spare operable seaming device will be maintained on site at all times.

3. Equipment used for seaming should not damage the geomembrane.
4. The geomembrane should be protected in areas of heavy traffic to prevent damage.
5. The extruder will be cleaned and purged prior to beginning seaming, and at any time that seaming operations are stopped, until all heat-degraded extrudate has been removed from the barrel.
6. The electric generator for the equipment will be placed on a smooth base in such a way that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric will be placed beneath the hot equipment after usage.
7. Grinding geomembrane surfaces for welding preparation shall not be performed more than 1 hour prior to seaming.

The installer and, if applicable, the geomembrane manufacturer will provide documentation to the CQA officer regarding the quality of the extrudate used in the welding apparatus. At a minimum, the extrudate should be compatible with the base liner material and contain the same grade and quality of polyethylene resin as used in the base material.

The installer will keep records for each seamer performing extrusion weld seaming, including welding machine I.D. number, extrudate, ambient air, and geomembrane surface temperatures. This data will be recorded at intervals as agreed to at the preconstruction meeting.

8.3.3 Initial Requirements

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests for the type of seaming equipment to be used. At least one seamer will have experience seaming a minimum of 1,000,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used at the landfill facility. The most experienced seamer, the "master seamer," will have direct supervisory responsibility at the job site over less experienced seamers.

The installer will provide a list of proposed seaming personnel and their experience records to the CQA officer and the RPR for their review and approval.

Weather Conditions

The range of weather conditions under which geomembrane seaming can be performed are as follows:

1. Unless otherwise authorized in writing by the CQA officer, no seaming will be attempted or performed at an ambient temperature below 32°F (0°C) or above 104°F (40°C).
2. Between ambient temperatures of 32°F (0°C) and 50°F (10°C), seaming will be performed only if the geomembrane is preheated by either sun or a hot air device to a temperature provided by the manufacturer, provided there is no excessive ambient cooling resulting from high winds.
3. Above 50°F (10°C), no preheating of the geomembrane is required.
4. Geomembrane will be dry and protected from the wind.
5. Seaming will not be performed during any precipitation event unless the installer erects satisfactory shelter to protect the geomembrane areas for seaming from water and/or moisture.
6. Seaming will not be performed in areas where ponded water has collected below the surface of the geomembrane.

If the installer wishes to use methods that may allow seaming at ambient temperatures below 32°F or above 104°F, the installer will demonstrate and certify that the methods and techniques used to perform the seaming produce seams that are entirely equivalent to seams produced at temperatures above 50°F and below 104°F, and that the overall quality of the geomembrane is not adversely affected.

The RPR will document the following items:

1. Ambient temperature at which seaming is performed.
2. Any precipitation events occurring at the site, including the time of such occurrences, the intensity, and the amount of the event.

The RPR will inform the CQA officer if any of the weather conditions are not being fulfilled. The CQA officer will cause to cease or postpone the geomembrane seaming when weather conditions are unacceptable.

Overlapping and Temporary Bond

The installer will be responsible for the following:

1. Panels of geomembranes have a finished overlap of a minimum of 3 inches for extrusion welding and 4 inches for fusion welding; but, in any event, sufficient overlap will be provided to allow peel tests to be performed on the seam.
2. No solvents or adhesives will be used on the geomembranes unless the product has been approved in writing by the CQA officer. Approval can only be obtained by submitting samples and data sheets to the CQA officer for testing and evaluation.
3. Procedures used to temporarily bond adjacent geomembrane rolls must not damage the geomembrane; in particular, the temperature of the hot air at the nozzle of any spot welding apparatus must be controlled such that the geomembrane is protected at all times against potential damage.

Trial Seams

Trial seams will be made on fragment pieces of geomembrane to document that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, and at least once every 4 hours thereafter, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams.

The trial seams will be examined by the installer for squeeze-out, foot pressure applied by seaming equipment, and general appearance. If the seam fails any of these examinations, it will be repeated until satisfactory seams are obtained.

The trial seam samples will be at least 3 feet long by 1 foot wide after seaming, with the seam centered lengthwise. Seam overlap will be as indicated above, under overlapping and temporary bond.

Two specimens, each 1-inch wide, will be cut from opposite ends of the trial seam sample by the installer. The specimens will be tested respectively in shear and peel using a field tensiometer provided by the installer, and they should not fail in the seam. If a specimen fails, the entire test will be repeated using two additional specimens cut from the trial seam sample or a new trial seam sample shall be made (with or without adjustments in the seaming process) and specimens cut for testing. If the second set of specimens also fails, the seaming apparatus and seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

The remainder of the trial seam sample will be identified and marked by the RPR as follows:

1. An assigned sample number, welding apparatus used, and seamer name
2. The date, time, applicable welding equipment operating temperatures, and ambient temperature at the time of seaming
3. Whether the sample passes or fails

The RPR may randomly select trial field samples for destructive testing by the Geosynthetic Testing Laboratory according to the test procedures described in Subsection 8.3.5 under field test methods. The frequency for trial seam laboratory testing will be at the discretion of the RPR.

If a trial seam sample fails a destructive test performed by the Geosynthetic Testing Laboratory according to the acceptance criteria stated in Subsection 8.3.5, then a destructive test seam sample(s) will be taken from each of the seams completed by the seamer during the shift related to the failed trial seam test. These samples will be forwarded by the RPR to the Geosynthetic Testing Laboratory and, if any of them fails the tests, the procedures described in Subsection 8.3.5 will apply. The conditions of this paragraph will be considered met if a destructive seam test sample, collected and tested according to the provisions under location and sampling frequency and sampling procedure of Subsection 8.3.5, has already been taken and passed.

Seam Preparation

The installer will meet the following conditions for each of the geomembrane installations covered by this plan:

1. Prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.
2. If seam overlap grinding is required, the grinding process will be completed according to the geomembrane manufacturer's instructions within 1 hour of the seaming operation, and in a way that will not damage the geomembrane or cause excessive striation of the geomembrane surface.
3. Seams will be aligned so as to minimize the number of wrinkles and "fishmouths."

General Seaming Procedures

Unless otherwise specified, the general seaming procedures to be used by the installer for each of the geomembrane installations covered by this plan, and observed by the RPR, will be as follows:

1. A firm substrate will be provided to achieve proper support for seaming.
2. Fishmouths or wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles will be seamed, and any portion where the overlap is inadequate will then be patched with an oval or patch of the same geomembrane (including thickness) extending a minimum of 6 inches beyond the cut in all directions.
3. If seaming operations are to be conducted at night, adequate illumination will be provided.

8.3.4 Nondestructive Testing

Each field seam will be nondestructively tested over its full length using one of the methods described in this section. The purpose of nondestructive testing is to determine the continuity of the seams. Nondestructive testing, at this stage of development, does not provide any information on the strength of seams. Seam strengths will be determined by destructive testing methods that are described in Subsection 8.3.5. Failure of any of the nondestructive or destructive tests will require the repair of the failed section according to the procedures contained in Subsection 8.3.5.

Nondestructive testing as described in this section will be performed on seams for every geomembrane installation covered by this plan. The recommended test methods for conducting the nondestructive seam testing are the air pressure test for dual hot wedge seams and the vacuum box test for extrusion fillet welds. These two nondestructive testing methods are described below.

The RPR will perform the following:

1. Observe all nondestructive seam testing, and examine all seams for squeeze-out, foot pressure, and general appearance. Failure of these criteria based on the RPR's judgment will be considered as failure of the seam, and repair or reconstruction will be required.
2. Document location, date, test unit number, name of tester, and outcome of all testing.
3. Inform the installer and CQA officer of any required repairs.

4. Document that appropriate repairs are made and that the repairs are retested nondestructively with passing results.

Air Pressure Testing

The following test procedures are applicable only to dual hot wedge seams. The equipment for performing the test should meet the following minimum requirements:

1. An air compressor or hand pump equipped with a pressure gauge and regulator capable of producing and sustaining a pressure between 25 to 30 psig and mounted on a cushion to protect the geomembrane surface.
2. Fittings, rubber hose, valves, *etc.*, to operate the equipment, and a sharp hollow needle or other approved pressure feed device.

Air pressure testing will be performed according to the following procedure:

1. Seal both ends of the seam to be tested.
2. Insert needle or other approved pressure feed device into the air space at one end of the dual hot wedge seam.
3. Energize the air compressor or hand pump to a pressure of 25 to 30 psig. Close the valve and observe the pressure response in the seam air space for approximately 7 minutes. The pressure should stabilize within the first 2 minutes and then remain essentially constant.
4. Record the pressure in the seam at the end of 2 minutes and again at the end of 7 minutes.
5. If the subsequent pressure loss exceeds 2 psig over the last 5-minute period or if the pressure does not stabilize, then the seam fails, and the defect must be located, repaired, and retested nondestructively.
6. If pressure loss does not exceed 2 psig over the last 5-minute period, then the seam is considered to have passed the nondestructive test provided the installer has verified that the air channel tested was not obstructed by noting a release of air pressure at the end of the tested seam interval opposite the pressure gauge.

Vacuum Box Test

Vacuum box testing is to be used on those seams made by the extrusion fillet process, to locate precisely the defects identified from air pressure testing, or to evaluate suspect seam and non-seam areas as discussed in Subsection 8.2.4.

Vacuum box testing equipment must meet the following minimum standards:

1. A five-sided vacuum box with an open bottom, a clear viewing panel on top, and a pliable gasket attached to the bottom.
2. A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections capable of achieving a vacuum of 10 psig.
3. A vacuum gauge on the tank with an operating range of 0 to 10 psig, and a vacuum gauge on the vacuum box with an operating range from 0 to 10 psig.

The following procedures will be used in performing the vacuum box test:

1. Ensure seams to be tested are clean and relatively free from soil or foreign objects that might prohibit a good seal from being formed between the vacuum chamber and the geomembrane.
2. Energize the vacuum pump and create a vacuum in the tank of 5 to 10 psig.
3. Wet a strip of geomembrane approximately twice the size of the vacuum box with the soapy solution.
4. Place and center the vacuum box with the gasket in contact with the geomembrane surface over the wetted area of the seam.
5. Applying a normal force to the top of the vacuum box, close the bleed valve, and open the vacuum valve. Check to make certain that a tight seal is created between the geomembrane and the vacuum box. A minimum vacuum of 5 psig should be used for testing with the maximum allowable testing pressure never exceeding 10 psig of vacuum.
6. With the vacuum drawn, use the viewing panel to examine the geomembrane seam for bubbles resulting from the flow of air through the seam. Continue this examination for not less than 10 seconds.
7. Remove the vacuum box by first closing the vacuum valve and opening the bleed valve. Proceed to step 8 if bubbles appear in Step 6. If no bubbles appear in step 6, then proceed directly to Step 9.
8. If bubbles appear through the geomembrane, mark the defective area for repair according to the provisions of Subsection 8.2.4. All repairs must be tested with passing nondestructive results.
9. Move the vacuum box along the seam to be tested, overlapping the previously tested area by no less than 3 inches.

8.3.5 Destructive Seam Testing

Destructive seam testing will be performed on the geomembrane seams covered by this plan. Destructive seam testing is performed to determine the strength of the seam in both shear and peel failure modes. Destructive seam testing will be performed within 48 hours of sampling either in an on-site laboratory by personnel under the direction of the CQA officer or at the Geosynthetic Testing Laboratory.

Location and Sampling Frequency

The RPR will select locations where seam samples will be cut out for the destructive testing. Test locations will be determined during seaming at the RPR's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential causes of an imperfect seam. The installer will not be informed in advance of any location where seam samples will be taken.

The minimum frequency of sample collection will be one test location per every 500 linear feet of seam length. This minimum frequency is to be taken as an average for the entire installation area.

Sampling Procedure

Samples will be cut under the direction of the RPR as the seaming progresses. For each sample location, information will be documented as follows:

1. Assign a sample number and mark accordingly.
2. Record sample location on the layout drawing.
3. By sample number, record the reason for collecting the sample (*e.g.*, as part of statistical testing program, suspicious seam, *etc.*).
4. Note on the sample, for the peel test, which geomembrane is the top and which is the bottom with respect to seams performed using dual hot wedge (fusion) weld techniques.
5. Record pertinent information including date, time, seaming unit number, and name of seamer.

Specimens for qualitative field testing will be taken prior to removal of the laboratory sample. Samples for field tensiometer testing will be 1 inch wide by 16 inches long with the seam centered parallel to the width. The distance between the two samples should be 42 inches measured from inside edge to inside edge. If both samples pass the field tensiometer test described below under field test methods, then the sample for laboratory testing will be taken according to the procedure described below.

The sample for laboratory testing will be located between the two samples used for field testing. Therefore, the laboratory sample will be 12 inches wide by 42 inches long with the seam centered lengthwise. The sample will be cut by the RPR into three parts and distributed as follows:

1. A 12-inch-by-16-inch sample will be given to the installer for testing if so desired.
2. A 12-inch-by-16-inch sample will be given to the owner for record storage.
3. An 8-inch-by-16-inch sample will be transmitted to the Geosynthetic Testing Laboratory or on-site testing laboratory by the RPR.

The RPR will make periodic reports to the installer detailing the locations of samples taken that must be repaired.

All holes cut into the geomembrane resulting from destructive seam sampling will be immediately repaired by the installer in accordance with the repair procedures described in Subsection 8.2.4. The repaired area will be nondestructively tested in accordance with the requirements of Subsection 8.3.4.

Field Test Methods

The two 1-inch-wide samples described above under sampling procedure will be field tested for both peel and shear. Testing will be performed using a field tensiometer or equivalent device to qualitatively determine the mode of failure. The seam will be considered as passing if the failure in both peel and shear does not occur with the seam. If the samples fail the field tensiometer test, then the repair procedures of Subsection 8.2.4 for the holes left by the cut-out samples, and seam reconstruction procedures for the repair of the defective seam, discussed later in this subsection, must be implemented.

Laboratory Test Methods

Laboratory testing of the destructive seam samples will be performed by the Geosynthetic Testing Laboratory or on-site testing laboratory under the direction of the CQA officer. All destructive seam tests, whether performed on trial seam samples (as described above) or on samples cut out from production seams, will be performed in general accordance with the methodology of

ASTM D 4437, which stipulates that at least five specimens should be tested in shear and five in peel. Samples will be cut in alternating order (*e.g.*, shear and peel, peel and shear) and should be tested in the order of cutting, to determine if any trend in seam quality along the length of the sample exists. All specimens will be cut as 1-inch-wide strips to ensure that the seam does not exceed the test gauge length of the specimen.

The following tests will be performed on each seam sample submitted for laboratory testing:

1. *Shear and peel maximum tension* is the maximum load per unit width of a 1-inch-wide specimen expressed in pounds per inch of width in both the shear and peel mode, according to ASTM D 4437.
2. *Shear elongation at break* is the extension at break expressed as a percentage of the initial distance between the edge of the fused track and the nearer grip. This distance should be the same on both sides of the seam and is usually 1 inch. No referenced ASTM test exists for this procedure as defined. The value that failure occurred will be noted on the results.
3. *Peel seam separation* estimates the area of seam interface separation expressed as a percentage of the original area.

Also, for both the seam shear and peel tension tests, an indication will be given for each specimen tested that defines the locus of the failure. The loci will be defined per ASTM 4437.

For the seam shear tests, specimens should be inserted in the test machine with minimum gauge lengths of ½ inch between each edge of the seam and the adjacent grip. The crosshead speed will be 2 inches per minute for HDPE and 20 inches per minute for VFPE. Parameters monitored during the test will be load and crosshead displacement.

For the peel tests, specimens will be inserted in the tensile machine so the grips are no closer than 1 inch to the edge of the seam. The grips may be closer than 1 inch only if there is insufficient material to allow insertion at this setting. Seam peel specimens will be tested at 2 inches per minute crosshead speed for HDPE and 20 inches per minute for VFPE.

For shear tests, the following values will be reported for each specimen tested:

1. Maximum tension in pounds per inch
2. Elongation at break indicating at what percentage the specimen failed

3. The locus of failure using the above designations

For peel tests, the following values will be reported for each specimen tested:

1. Maximum tension in pounds per inch
2. Seam separation expressed as percent of original seam area
3. Locus of failure

For each set of five specimens, the mean and standard deviation will be calculated and reported for shear maximum tension and peel maximum tension.

Role of Testing Laboratory

The Geosynthetic Testing Laboratory or on-site testing laboratory will be responsible for performing the tests on samples submitted to them as described above. Results of tests performed will be reported to the CQA officer and the RPR. Retesting of seams, because of failure to meet any or all of the specifications listed below, can only be authorized by the CQA officer.

The geomembrane manufacturer and/or installer may perform their own QC testing in accordance with the methods and procedures defined above under laboratory test methods; however, the results, if substantially different from those obtained by the Geosynthetic Testing Laboratory or on-site laboratory, may only be used to request a retesting by the Geosynthetic Testing Laboratory or on-site testing laboratory. All QA test results from the Geosynthetic Testing Laboratory or on-site laboratory govern, over any test results from the geomembrane manufacturer of installer. Only the CQA officer is authorized to approve a retesting request.

Procedures for Determining Destructive Seam Test Failures

The procedures described in this section apply to the destructive testing procedures defined above under field test methods and laboratory test methods. Specifications for destructive seam testing are shown in Table 8-7 and Table 8-8. Procedures for repairing failed seams are given in Subsection 8.2.4 of this plan.

Results from the shear and peel tests for the HDPE geomembrane will be evaluated by criteria, which are based on the values for material properties for yield stress (Note: yield stress of the base geomembrane is considered a more representative criterion than bonded seam strength) from Table 1a and Table 2a of GRI-GM13 standards.

Results from the shear and peel tests for the VFPE will be evaluated by the following criteria:

1. Minimum acceptable individual specimen shear elongation values will be no less than 50 percent.
2. Maximum allowable individual specimen peel separation value will be 10 percent.
3. Failure type in peel must be film-tear bond (FTB) for 4 out of 5 test specimens.

The installer has the following two options in determining the repair boundary whenever a seam has failed: either the field tensiometer testing or laboratory destructive testing:

1. The seam can be reconstructed between any two previously tested and passed destructive seam test locations.
2. The installer can trace the welding path to an intermediate location (at a 10-foot minimum from the point of the failed test in each direction) and request that field tensiometer tests be performed at these intermediate locations. If the field tensiometer sample results are acceptable, then full laboratory samples are taken and tested. If the laboratory tests are acceptable, then the seam is reconstructed between these intermediate locations. If either sample fails, then the process is repeated until acceptable destructive seam tests have been performed in both directions away from the original failed sample location. All retesting of seams, according to this procedure, will use the sampling methodology described above under Sampling Procedure.

For all seams reconstructed due to a failing destructive seam sample, an additional sample taken from the reconstructed zone must pass destructive seam testing.

The RPR will be responsible for documenting all actions, including test results submitted by the Geosynthetic Testing Laboratory, taken in conjunction with seam testing. The RPR will also be responsible for keeping the CQA officer informed on seam testing results and seaming progress.

8.4 Post-Construction

Each geomembrane covered by this plan will be examined by the RPR. Any defects, whether due to failed seams, pinholes, or other penetrations, will be repaired. In addition, a stress crack examination will be performed along the seams of all the geomembrane installations covered by the plan.

This examination, by experienced personnel, will utilize the procedures described in the USEPA Field Inspector's Manual titled *Stress Cracking of Flexible Membrane Liner Seams*. This document identifies three levels of stress crack development with Level #1 being those that can be observed only under a microscope, Level #2 being those that are barely visible to the eye, and Level #3 being those that are complete fractures.

The geomembranes covered by this plan will be examined for Level #2 and Level #3 stress cracks according to the procedure described in the Field Inspector's Manual under the heading "Field Inspection Recommendations." This examination will be performed by experienced personnel only. Any Level #2 or Level #3 stress cracks found will be immediately marked by the RPR and will be repaired according to the provisions of Subsection 8.2.4.

Placement of the Geocushion™ drainage layer material shall proceed as soon as practical following the RPR's testing and acceptance of completed geomembrane areas. The granular layer will provide ultraviolet protection, thermal insulation, and protection from physical damage.

Table 8-1
Number of Units to be Selected as Lot Sample—Specification Conformance

NUMBER OF UNITS IN LOT	NUMBER OF UNITS SELECTED
1 to 2	1
3 to 8	2
9 to 27	3
28 to 64	4
65 to 125	5
126 to 216	6
217 to 343	7
344 to 512	8
513 to 729	9
730 to 1,000	10
1,001 or more	11

Table 8-2
High-Density Polyethylene Geomembrane Tests And Test Methods

PROPERTY	TEST METHOD
Carbon Black Content	ASTM D 4218
Carbon Black Dispersion	ASTM D 5596
Density	ASTM D 792 or D1505
Tear Resistance (1)	ASTM D 1004
Puncture Resistance	ASTM D 4833
Tensile Properties(1) Yield Stress Yield Elongation Break Stress Break Elongation	ASTM D 638, Type IV specimen at 2 inches/minute
Single-Point Notched Constant Tensile Load (SP-NCTL)	ASTM D 5397
Thickness	ASTM D 5199 (smooth) ASTM D 5994 (textured)

(1) These tests will be performed and results reported for both machine and cross direction.

Table 8-3
Very Flexible Polyethylene Geomembrane Tests and Test Methods

PROPERTY	TEST METHOD
Carbon Black Content	ASTM D 4218
Carbon Black Dispersion	ASTM D 5596
Density	ASTM D 792, Method A; or ASTM D 1505
Tear Resistance [(1)]	ASTM D 1004
Puncture Resistance	ASTM D 4833
Tensile Properties [(1)] Yield Stress Yield Elongation Break Stress Break Elongation	ASTM D 638, Type IV specimen at 2 inches/minute
Single-Point Notched Constant Tensile Load (SP-NCTL)	ASTM D 5397
Thickness	ASTM D 5199 (smooth) ASTM D 5994 (textured)

(1) These tests will be performed and results reported for both machine and cross direction.

Table 8-4
High-Density Polyethylene Geomembrane 60-Mil Acceptance Specifications

PROPERTY	UNITS	TYPE OF CRITERION	ACCEPTABLE VALUE [1]
Carbon Black Content	% by weight	Range	2 – 3
Carbon Black Dispersion	N/A	Range	Category 1, 2, or 3 [2]
Density	g/cc	Minimum	0.940
Tear Resistance [3]	lb	Minimum	42
Puncture Resistance	lb	Minimum	90
Tensile Properties [4]			
Yield Stress	ppi	Minimum	126
Yield Elongation	%	Minimum	12
Break Stress	ppi	Minimum	228 (90) [4]
Break Elongation	%	Minimum	700 (100)
SP-NCTL	hours	Minimum	200
Thickness [5] (lowest individual)	mils	Minimum	54 (51) [6]
Thickness (minimum average)	mils	Average	60

(1) Values are from Table 1a and Table 2a of GRI-GM13 standards
(2) Eight of 10 views Category 1 or 2, and 10 of 10 views Category 1, 2, or 3.
(3) Test is performed in both machine and cross direction.
(4) Parenthetical values are for textured geomembranes.
(5) For smooth geomembrane, lowest individual value of 10 values; for textured geomembrane, lowest individual value for 8 of 10 values.
(6) For textured geomembrane, lowest individual value of any 10 values.

Table 8-5
Very Flexible Polyethylene Geomembrane 40-Mil Acceptance Specifications

PROPERTY	UNITS	TYPE OF CRITERION	ACCEPTABLE VALUE (1)
Carbon Black Content	% by weight	Range	2 - 3
Carbon Black Dispersion	N/A	Range	Category 1, 2, or 3 (2)
Density	g/cc	Minimum	0.910 – 0.935
Tear Resistance (3)	lb	Minimum	22
Puncture Resistance	lb	Minimum	52
Tensile Properties (3) Break Stress Break Elongation	 ppi %	 Minimum Minimum	 152 (72) (4) 625 (200) (4)
SP-NCTL	hours	Minimum	1,500
Thickness (5) (lowest individual)	mils	Minimum	36 (34) (6)
Thickness (minimum average)	mils	Average	40

(1) Values based on representative manufacturer's product data.
(2) Eight of 10 views Category 1 or 2, and 10 of 10 views Category 1, 2, or 3
(3) Test performed in both machine and cross direction.
(4) Parenthetical values are for textured geomembrane.
(5) For smooth geomembrane, lowest individual value of 10 values; for textured geomembrane, lowest individual value for 8 of 10 values.
(6) For textured geomembrane, lowest individual value for any of the 10 values.

Table 8-6
60-Mil Smooth or Textured High-Density Polyethylene Geomembrane Seam Acceptable Specifications

PROPERTY	TEST METHOD	UNITS	TYPE OF CRITERION	MINIMUM AVERAGE VALUE (1)	
				NONTEXTURED	TEXTURED
Shear Strength (2)	ASTM D 4437	ppi	Minimum	126	113
Shear Elongation	--	percent	Minimum	50	50
Peel Strength (2) Fusion	ASTM D 4437	ppi	Minimum	90	82
Peel Strength (2) Extrusion	ASTM D 4437	ppi	Minimum	78	70
Peel Separation (3)	--	percent	Maximum	10	10

(1) The average of all five specimen test results must meet these requirements. In addition, five out of the five test results must meet these requirements.
(2) Failure type in peel must be film-tear bond (FTB) for four out of five test specimens.
(3) Maximum acceptable value.

Table 8-7
40-Mil Very Flexible Polyethylene Smooth or Textured Geomembrane Seam Acceptable Specifications

PROPERTY	TEST METHOD	UNITS	MINIMUM AVERAGE VALUE [1]	
			NONTEXTURED	TEXTURED
Shear Strength [2]	ASTM D 4437	ppi	44	40
Shear Elongation [2]	—	percent	50	50
Peel Strength [3, 4] Fusion	ASTM D 4437	ppi	40	36
Peel Strength [3,4] Extrusion	ASTM D 4437	ppi	36	36
Peel Separation [5]	—	percent	10	10

(1) If the lengthwise edges of the textured geomembrane panels are nontextured, then the nontextured specifications shall apply for the testing of seams made along these edges.
(2) Five out of the five test specimens must meet these requirements. In addition, failure type must be FTB for all five specimens.
(3) Four out of the five specimens must meet the three requirements. The fifth specimen shall achieve 90 percent of the listed peel strength.
(4) Failure type must be FTB for four out of five test specimens.
(5) Maximum Acceptance Value for four out of five test specimens. The fifth specimen shall have no more than 50 percent peel separation.

Section 9
Geonets

Geonets will be part of a geocomposite consisting of a non-woven geotextile heat bonded to the geonet. The geonets used in the geocomposites will meet the applicable requirements of this section. Geocomposites are discussed in Section 11.

As geonets will not be used independently (*i.e.*, only used as a component of the geocomposite), portions of this section are not applicable. Section 9 (Geonets) is included to provide a reference source for geonet material specifications and testing requirements as called for in Section 11.

This section is divided into three major subheadings that cover the QA requirements for pre-installation (includes geonet manufacturers), installation, and post-installation (includes the final examination of the geonets prior to placing the appropriate material above the geonet). The terms pre-installation, installation, and post-installation are applicable only to the geonet installation and do not apply to the overall construction of the landfill facility.

9.1 Pre-installation

9.1.1 Manufacturing

Material Specifications

The geonets used must be fabricated from polyethylene resin, and the fabricated geonet must be classified as Type III, Class C, Category 4 or 5 as defined by ASTM D 1248 (Note: this classification is based on tests performed on the finished product, ***not*** the polyethylene resin used to fabricate the geonet).

Quality Control Requirements

Prior to the delivery of any geonet rolls to the site, the geonet manufacturer will provide the CQA officer with the following information:

1. The resin supplier, location of supplier's production plant(s), and resin brand name and product number.
2. Test results obtained by the geonet manufacturer and/or the resin manufacturer's testing laboratories to document the quality of the resin used in fabricating the geonet.

3. The QC plan that the geonet manufacturer will be using for the geonet being supplied.

Every roll of geonet for delivery to the site must be manufactured and inspected by the geonet manufacturer, according to the following requirements:

1. First-quality polyethylene resin must be used.
2. The geonet must contain no more than a maximum of 1 percent by weight of additives, fillers, or extenders, excluding carbon black.
3. The geonet must have no striations, roughness, or cuts on the surface.
4. The geonet must be free of blisters, undispersed raw materials, or any other sign of contamination by foreign matter.

The geonet manufacturer will routinely perform the following tests on the raw resin, at the stated frequencies, and will report the results on a periodic basis to the CQA officer:

1. Collect and test a minimum of one sample for the parameters in Item #2 below for every 50,000 pounds of resin received.
2. Perform carbon black content by ASTM D 4218, carbon black dispersion by ASTM D 2663 Method B, specific gravity by ASTM D 792 Method A, melt flow index by ASTM D 1238 with a load of 2.16 kg and at 190°C, and moisture content by any approved method.

Manufacturer's Certification

The geonet manufacturer will provide certification, based on tests performed in accordance with the methods listed in Table 9-1 that the geonet supplied under this plan will meet the material specifications listed in Table 9-1. These tests may be performed at a minimum frequency of 1 per 100,000 square yards of material delivered to the site by the geonet manufacturer's laboratory or by a laboratory contracted by the manufacturer. Additionally, the manufacturer shall provide certification that the manufacturer's QC plan was fully implemented for the geonet materials supplied under this plan. The manufacturer shall provide documentation to verify the results of the manufacturer's CQA plan implementation if requested by the CQA officer.

9.1.2 Delivery, Handling, and Storage of Geonet Rolls

Each geonet roll for use at the landfill facility will be marked by the geonet manufacturer with the following information and in the following manner:

1. When the net is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
2. Each roll label will contain the following information at a minimum:
   - Name of manufacturer (or supplier)
   - Style and type number
   - Roll length and width
   - Batch (or lot) number
   - Nominal product thickness
   - Date of manufacture
   - Direction for unrolling
   - Roll number
3. On the outside of the roll, all lettering should be a minimum ½ inch high; and on the inside of the core, the lettering should be at least ¼ inch high.

The geonet manufacturer will use the following guidelines in packaging and preparing all geonet rolls for shipment:

1. When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
2. Geonets must be rolled on the cores so that they will unroll in the machine direction. The machine direction is defined as the direction parallel with the longest diagonal in the diamond pattern of the geonet.

The following practices should be used as a minimum in receiving and storing geonet rolls in the designated storage area at the job site:

1. While unloading or transferring the geonet rolls from one location to another, prevent damage to the geonet. If practicable, the installer may use forklift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least $^{2}/_{3}$ the length of the rolls to avoid breaking the cores and possibly damaging the geonet. Do not drag the rolls.

2. Store the geonet rolls to ensure that they are adequately covered to protect the geonet from the following:
    - Precipitation
    - Ultraviolet radiation, including sunlight
    - Strong oxidizing chemicals, acids or bases
    - Flames, including welding sparks
    - Temperatures in excess of 160°F
    - Soiling

The RPR will observe and document throughout the pre-installation, installation, and post-installation periods that the installer provides adequate handling equipment used for moving geonet rolls and that the equipment and handling methods used do not pose unnecessary risk of damage. The installer is responsible for means and methods to implement the work.

The installer will be responsible for ensuring that materials installed meet specifications (*i.e.*, the roll marking label information indicates required specifications and properly represents materials). The RPR will maintain a log of geonet roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job site:

1. Date of shipment from geonet manufacturer
2. Date of receipt of delivery at job site
3. For each geonet roll the following information will be noted:
    - Roll number
    - Batch (lot) number

9.2 Installation

This section describes the QA requirements applicable to the installation of geonets. This section includes installation, observations, and documentation of geonets.

9.2.1 Placement

The installer will install all geonets in such a manner as to ensure that they are not damaged in any way and in a manner that complies with the following:

1. On sideslopes, the geonets will be securely anchored, then rolled down the slope in such a manner as to continually keep the geonet in tension. If necessary, the geonet will be positioned by hand after being unrolled to minimize wrinkles.
2. In the presence of winds, all geonets will be secured by suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
3. Cutting should be done according to manufacturer's recommendations.
4. The installer will take necessary precautions to prevent damage to underlying layers during placement of the geonet.
5. During placement of geonets, care will be taken not to entrap in the geonet any stones, excessive dust, or moisture that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geonet, the geonet will be cleaned prior to placement of the next material on top of the geonet.
6. Unless otherwise approved by the CQA officer, geonets will not be welded or tack welded to the underlying geomembranes.

9.2.2 Stacking and Joining

When several layers of geonets are stacked, care should be taken to prevent strands from one layer from penetrating the channels of the adjacent layer, thereby significantly reducing the transmissivity. This cannot happen if stacked geonets are placed in the same direction. A stacked geonet should not be laid in a perpendicular direction to the underlying layer.

The following guidelines should be used in stacking and joining geonets:

1. Adjacent rolls will be overlapped by a minimum of four inches.
2. These overlaps will be secured by spot-welding to each other or tying.
3. Tying can be achieved by strings, plastic fasteners, or polymer braid. Tying devices will be white or brightly colored for easy identification. Metallic devices will not be used in any circumstances.

9.2.3 Repairs

Any tears or other defects in the geonet will be repaired by placing a patch extending a minimum of 2 feet beyond the edges of the hole or tear. The patch will be secured to the original geonet by spot-welding or tying every 6 inches. If the tear or other defect width is more than 50 percent of the roll width, the damaged area will be cut out and replaced with new geonet. Tying devices as indicated in Subsection 9.2.2 will be used. The RPR will examine and document that the repair of any geonets is performed according to the above procedure.

9.3 Post-Installation

9.3.1 Final Examination

The RPR will perform a final geonet examination after installation of each geonet layer has been completed. The objectives of this step are as follows:

1. Examine for presence of tears or defects.
2. Examine overlaps and tying or spot-welding.

If any portion of the geonet requires repairs due to the above examination, they will be performed according to the procedures in Subsection 9.2.3. The RPR will document the result of the final examination, including any subsequent repairs.

Table 9-1
Geonet Properties

PROPERTY	UNITS	FINAL COVER VALUE	LEACHATE COLLECTION LAYER VALUE	TEST METHOD	CRITERION
Thickness	mils	225	300	ASTM D 5199	Minimum
Density	g/cu cm	0.94	0.94	ASTM D 1505	Minimum
Melt Flow Index	g/10 min	1.0	1.0	ASTM D 1238	Maximum
Carbon Black Content	Percent	2 - 3	2 - 3	ASTM D 4218	Range

Section 10
Geosynthetic Clay Liner

10.1 Introduction

This section of the CQA plan applies to the geosynthetic clay liner used in the landfill base composite liner and in the composite final cover. This section is divided into three major subheadings, which cover the quality assurance requirements for pre-installation (includes the GCL manufacturer), installation, and post-installation (includes the final examination of GCL prior to the placement of the geomembrane). The terms pre-installation, installation, and post-installation are applicable only to the GCL installation and do not apply to the overall construction of the landfill facility.

10.2 Pre-installation

Pre-installation activities are designed to help ensure that a high-quality product is being manufactured and that it is properly delivered, handled, and stored to maintain its quality.

10.2.1 Manufacturer's Quality Control Plan

The manufacturer of each component of the GCL and the GCL itself will have a manufacturer's quality control plan (MQCP) to ensure that their product meets all of the stated minimum properties. These manufacturers include the bentonite supplier, the geotextile manufacturer, and the GCL manufacturer.

Bentonite Supplier

The bentonite supplier will have a MQCP that will be adhered to in the manufacturing process. This plan will include the following information:

1. Documentation that the bentonite is sodium bentonite
2. Testing that demonstrates that the bentonite meets specified gradation requirements
3. Testing that demonstrates that the bentonite meets specified index test requirements
4. Testing that demonstrates that the bentonite has not been treated with synthetic chemicals or polymers

Geotextile Manufacturer

The geotextile manufacturer will have a MQCP that will be adhered to in their manufacturing process. This plan will include the following provisions:

1. Testing that demonstrates that the product is made of specified polymers
2. Testing that demonstrates that the product meets certain minimum average roll values for geotextiles

GCL Manufacturer

The GCL manufacturer will have a MQCP that describes the procedures for accomplishing quality in the final product. At a minimum, the tests shown in Table 10-1 shall be performed by the manufacturer.

This MQCP will also dictate the following requirements:

- Overlap alignment lines are to be marked on the edges.
- Completed rolls are to be securely wrapped in plastic.
- Completed rolls are to be stored indoors, and provisions are to be in place to prevent rolls from being stacked too high, to ensure that they are kept dry, and to prevent damage during handling.
- QC certificates are to be provided.

10.2.2 Materials

The GCL will consist of a layer of pure sodium bentonite clay encapsulated between two geotextiles, and will comply with all of the manufacturing processes and physical/chemical criteria listed in this subsection.

The bentonite clay utilized in the manufacture of the GCL, as well as any accessory bentonite clay (*i.e.*, Volclay® granular sodium bentonite or approved equivalent) provided for seaming and detail work, will meet the manufacturer's minimum requirements, as specified in the MQCP.

The geotextile components of the GCL, and the GCL itself, will meet the minimum requirements of the respective MQCPs.

10.2.3 Geosynthetic Clay Liner Delivery, Handling, and Storage

The GCL panels will be supplied to the site in factory-produced rolls, which are of standard factory roll dimensions.

Each roll of GCL supplied to the site will be labeled with the following information:

1. Name of manufacturer
2. Product type and identification number (if any)
3. Lot (Batch) number
4. Date of manufacture
5. Roll number and dimensions

The GCL manufacturer will ensure that the crushing strength of all GCL roll cores will be sufficient to avoid collapse or other damage while in use.

The rolls of GCL will be carefully unloaded by the contractor upon arrival at the site. At a minimum, the following practices will be followed in receiving and storing GCL rolls in the covered storage area at the job site:

1. While unloading or transferring the GCL rolls from one location to another, precautions will be taken to prevent damage to the GCL.
2. For standard rolls, a 3-inch Schedule 120 steel support pipe will be inserted through the cardboard roll core. The slings or lifting chains will be attached at one end to the support pipe and at the other end to the bucket of a front-end loader or lifting device. A spreader bar will be used to support and spread the slings. The bar and support pipe must be long enough to prevent damage to the edges of the GCL during hoisting.
3. Alternatively, forklift trucks can be modified to lift the rolls with a 3-inch Schedule 120 steel bar, securely attached to the forklift and inserted into the roll core. At no time will the rolls be lifted by sliding the forks under the roll.
4. The rolls of GCL will be stored in their original, unopened, wrapped cover in a clean, dry area. The material will be stored off the ground on pallets or by other suitable techniques that provide continuous support over the entire length of the roll. It will be covered with a heavy, protective tarpaulin or stored beneath a roof. Care will be used to protect the GCL from the following:
    - Precipitation
    - Ultraviolet radiation, including sunlight
    - Strong oxidizing chemicals, acids or bases
    - Flames, including welding sparks
    - Temperatures in excess of 160°F

The RPR will be responsible throughout the pre-installation, installation, and post-installation periods, for observing and documenting that the installer provides adequate handling equipment used for moving GCL rolls and that the equipment and handling methods used do not pose any risk of damage.

The RPR will be responsible for making certain that the name of the manufacturer, the type, and the thickness of each roll (as noted on the roll marking label described above) are correct. The RPR will also maintain a log of GCL roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job site:

1. Date of receipt of delivery at job site
2. For each GCL roll, the following information will be noted:
    - Roll number
    - Batch (lot) number

10.2.4 Submittals

Submittals will be made prior to installation of the GCL concerning the GCL manufacturer/production information and the GCL installer information.

The GCL manufacturer/production information will include the following:

1. Corporate background and information.
2. MQCP for bentonite, geotextile, and GCL manufacturers.
3. Project reference list consisting of the principal details of at least 10 projects totaling at least 8 million ft^2 of GCL installation.
4. Results of tests conducted by the bentonite supplier and geotextile suppliers to document the quality of the materials used to manufacture the GCL rolls assigned to the project.
5. Copy of QC certificates, signed by a responsible entity of the manufacturer. Each quality control certificate will include roll identification numbers, and the results of quality control tests (refer to Subsection 10.2.1 above for minimum testing requirements).
6. Manufacturer’s written certification that the GCL meets the project specifications, that the GCL has been continuously inspected and found to be needle-free, that the bentonite will not shift during transportation or installation, and that the bentonite and geotextile materials meet the manufacturer's specifications

GCL installer information will include the following:

1. Corporate background information
2. Project reference list consisting of the principal details of at least five projects totaling at least 1 million ft^2
3. List of personnel performing field operations, along with pertinent experience information, if required by the RPR or CQA officer

The proposed panel layout diagram identifying placement of the GCL panels and seams, as well as any variances or additional details that deviate from the engineering drawings will also be submitted prior to installation. The layout will be drawn to scale, will include information such as dimensions and details, and will be adequate for use as a construction plan.

10.3 Installation

The following installation procedures are designed to ensure the effectiveness of the GCL in meeting its design requirements and to simplify the deployment procedures. These procedures are to be followed by the installer, unless the installer proposes alternative procedures in writing and the CQA officer approves them in writing prior to installation.

10.3.1 Testing Requirements

This subsection describes the test methods, including sampling procedures and frequencies, and the role of the Geosynthetic Testing Laboratory in testing the GCL roll samples. Unless specified otherwise, all sampling procedures will be performed in accordance with the referenced test method defined in this section.

GCL roll samples will be collected by the contractor at the discretion of, and under the direction of, the RPR, at a rate specified by the RPR.

Samples will be 3 feet long by the full width of the roll and will not include the first 3 feet of any roll.

Table 10-1 lists the tests and the test methods that may be performed on GCL roll samples. The specifications and methods used in evaluating the results are discussed later in this subsection.

Role of Testing Laboratory

The Geosynthetic Testing Laboratory will be responsible for performing the tests on samples submitted to them. The results of tests performed will be reported to the RPR and CQA officer.

Retesting of GCL rolls for quality assurance purposes, because of failure to meet any or all of the acceptance specifications in this section, can only be authorized by the CQA officer.

The GCL manufacturer and/or installer may perform their own tests according to the methods and procedures defined in Table 10-1; however, the results will only be applicable to their own quality control needs. These results will not be substituted for the quality assurance testing described herein.

Procedure for Determining GCL Roll Test Failures

Table 10-1 lists the specifications that are applicable to the GCL. For any referenced test method that requires the testing of multiple specimens, the criteria in Table 10-1 will be met based on the average results of the multiple specimen tests.

The following procedure will be used for interpreting the results relative to acceptance or rejection of rolls, lots, and shipments of GCL to the site:

1. If the test values meet the stated specifications, then the roll and batch will be accepted for use at the job site. If the sample represents all rolls from an entire shipment, then the entire shipment will also be considered accepted.
2. If the results do not meet the specification, then the roll and the batch will be retested at the contractor's expense using specimens either from the original roll sample or from another sample collected by the RPR. For retesting, two additional tests will be performed for the failed test procedure. (Each additional test will consist of multiple specimen tests if multiple specimens are called for in the failed test procedure.) If both of the retests are acceptable, then the roll and batch will be considered as having passed this particular acceptance test; if either of the two additional tests fail, then the roll and batch will be considered as being unsuitable without further recourse. The RPR may obtain samples from other rolls in the batch. On the basis of testing these samples, the CQA officer may choose to accept a portion of the batch while rejecting the remainder.

   If retesting does not result in passing test results as defined in the preceding paragraph, or if there is any other nonconformity with the material specifications, then the contractor will withdraw the rolls from use in the project at contractor's sole risk, cost, and expense. Once withdrawn, the same rolls will not be resubmitted for use. Expenses for removing this GCL from the site and replacing it with acceptable GCL will be the sole risk and responsibility of the contractor.

10.3.2 Required Equipment

The following installation equipment is required on site:

1. Front-end loader, crane, or other similar equipment. The selected piece of equipment will not cause damage to the subgrade, such as rutting. The installer will verify in the presence of the RPR that the selected piece of equipment does not damage the subgrade
2. A spreader bar to prevent slings from damaging the ends of the rolls.
3. 3-inch–diameter Schedule 120 steel pipes to be inserted into the roll's core for lifting.
4. Wooden pallets for aboveground storage of the GCL rolls.
5. Heavy waterproof tarps for protecting all GCL rolls.
6. Sandbags for securing the GCL during installation and for securing the tarps.
7. Adhesive or tape for securing patches.
8. Granular bentonite for seams and patches, and for securing around penetrations and structures as shown on the drawings.

10.3.3 Surface/Subgrade Preparation

GCL liner installation will not begin until a proper subbase has been prepared to accept the bentonite liner. Base material will be fine-grained soil free from angular rocks, roots, grass, and vegetation. Foreign materials and protrusions will be removed; all cracks and voids will be filled; and the surface will be made smooth and uniformly sloping. Unless otherwise required by the contract specifications, the prepared surface will be free from excessive moisture, loose earth, rocks or clay clods larger than ½ inch in diameter, rubble, and other foreign matter. The subgrade will be uniformly compacted to ensure against localized settlement and rutting under wheel loads and will be smoothed with a smooth drum roller.

The surface on which the liner is to be placed will be maintained in a firm, clean, and smooth condition, free of standing water, during liner installation.

10.3.4 Deployment

As each roll is moved from the storage area, the labels will be removed by the installer's Superintendent or RPR for storage in the project file.

The rolls of GCL will be brought to the area to be lined with a front-end loader, and support pipe will be set up such that the roll of liner is fully supported across its length. A spreader bar or similar device will be used to prevent the lifting chains or slings from damaging the edges. Dragging of the GCL liner will be minimized.

The contractor will ensure, and the RPR will verify, that the following criteria are being met:

1. The equipment used does not damage the GCL by handling, excessive heat, leakage of hydrocarbons, or by other means.
2. The prepared surface underlying the GCL has not deteriorated since previous acceptance, and it is still acceptable at the time of GCL placement.
3. Personnel working on the GCL do not smoke, wear damaging clothing, or engage in other activities that could damage the GCL.
4. The method used to unroll the GCL does not cause damage to the GCL, and/or the subgrade.
5. The method used to place the rolls minimizes wrinkles (especially wrinkles between adjacent panels).

GCL must not be placed during precipitation events, in the presence of excessive moisture, in any area of ponded water, or during excessive winds. The GCL must be dry when installed and must be dry when covered with soil.

The proper side of the GCL, as per the manufacturer's recommendation, will face upward (unless otherwise dictated by project requirements). The liner will be placed over the prepared surface such that material handling will be minimized.

The GCL panels will be placed in a manner that ensures sufficient overlap as described in Subsection 10.3.5. Horizontal seams will not occur on slopes steeper than 7 horizontal: 1 vertical.

The cover material (*i.e.,* geocomposite and soil) will be placed over the bentonite liner during the same day as the placement of the GCL. Only those GCL rolls that can be covered that same day will be unpacked and placed in position.

When wind conditions could affect installation, the GCL liner installation will be started at the upwind side of the project and will proceed downwind. The leading edge of the liner will be secured at all times with sandbags or other means sufficient to hold it down during high winds.

The GCL will be installed in a relaxed condition and will be free of tension or stress upon completion of the installation. Stretching of the liner to fit will not be allowed. Deployed rolls (panels) will be straightened by the installation personnel to smooth out creases or irregularities.

The RPR will visually inspect the geotextile's quality, the bentonite uniformity, and the degree of hydration, if any, of the GCL. Any areas in need of repair will be marked.

10.3.5 Seaming

Once the first panel has been deployed, adjoining panels will be laid with a 6-inch minimum overlap on longitudinal seams, and 24 inches on the panel end seams. Six-inch and 12-inch overlap lines will be marked on the liner to assist in obtaining the proper overlap. All dirt, gravel, or other debris will be removed from the overlap area of the GCL.

Seam overlaps, whenever possible, will be placed such that the direction of flow is from the top panel to the underlying panel to form a shingle effect.

If the GCL requires a granular bentonite seam, then the overlapping panel edge will be pulled back and granular Volclay® (or approved equivalent) sodium bentonite will be poured continuously along all seams and lap areas from the panel edge to the 6-inch lapline, at a minimum application rate of ¼ pound per linear foot.

10.3.6 Patches/Repairs

Irregular shapes, cuts, or tears in the installed GCL will be covered with sufficient liner to provide a 12-inch overlap in all directions beyond the damaged area. A layer of granular bentonite will be placed in the overlap zone in accordance with the manufacturer's recommendations. An epoxy-based adhesive, or other approved method, will be used to secure the patch during backfill operations. Alternatively, the patch can be placed underneath the defective liner.

Patch repairs should not be allowed on slopes greater than 7 horizontal: 1 vertical, unless a water-soluble adhesive, or other approved method, is used to secure the patch.

10.3.7 Penetration Seals

The GCL will be sealed around penetrations, pipes, and structures in accordance with the recommendations of the GCL manufacturer.

Pipe penetrations will incorporate a collar of GCL wrapped around the pipe and securely fastened. A bentonite or mastic grout will be placed around the corners for additional protection.

Depending on the location of the pipe penetration, an additional GCL skirt placed over the bentonite grout may be required by the GCL manufacturer to provide a third level of protection and to prevent the bentonite grout from being displaced.

If the seal requires granular bentonite, then a 1-inch to 2-inch cut will be excavated around the circumference of the pipe, into the subgrade at least 12 inches out from the pipe. Volclay® sodium bentonite (or approved equivalent) will then be packed around the pipe in the subgrade excavation and on adjacent areas so that the pipe is surrounded with granular bentonite.

The GCL panel will then be placed over the pipe by penetrating the GCL with slits in a "pie" configuration where the pipe is to protrude in a manner that will create a snug fit between the GCL and the pipe.

More sodium bentonite will then be spread around the cut edges of the GCL against the pipe and over adjacent areas.

To complete the pipe penetration seal, a collar of GCL will be cut in a manner similar to that made on the main panel and will be fit around the pipe, with additional Volclay® sodium bentonite being applied into any gaps that may remain.

10.3.8 Covering Geosynthetic Clay Liner

Only the amount of GCL that can be inspected, repaired, and covered in the same day will be installed. The GCL must be covered the same day on which it is installed.

Geosynthetics

When covering the GCL, precautions will be taken to prevent damage to the GCL by restricting heavy equipment traffic. The following requirements apply to material placement over the GCLs:

1. Equipment used for placing the material must not be driven directly on the GCL.

2. A minimum thickness of 0.6 feet of fill is specified between a light dozer (*i.e.*, maximum contact pressure of 5 lb/sq. inch) and the geocomposite or Geocushion™ on top of the composite liner (*i.e.*, geomembrane overlying a GCL).
3. A minimum thickness of 3 feet of fill is specified between rubber-tired vehicles and the composite liner.

Any leading edge or panels of GCL left unprotected must be covered with a heavy, waterproofing tarp that is secured and protected with sandbags or other ballast.

10.3.9 Construction Quality Assurance

Installer

The installer will maintain documentation in the daily installation records, and will provide such documentation to the RPR that the above conditions are fulfilled. The RPR will be informed if any of the above conditions are not met.

The GCL will be installed according to the manufacturer's guidelines, the CQA plan, and the project specifications.

Resident Project Representative

The RPR will be responsible for the following quality assurance duties:

1. Observation of the installation of the GCL for compliance with the manufacturer's guidelines, the CQA plan, and the project specifications.
2. Collection of the field acceptance samples to be tested as indicated in Table 10-2.
3. Visual inspection of the geotextile quality, bentonite uniformity, and degree of hydration, if any, on the GCL. Any areas in need of repair will be marked.
4. Recording each roll number and lot number as panels are deployed, along with a general description of the location of each panel.
5. Inspection of the overlaps.
6. Inspection of the anchoring and sealing around penetrations.

10.3.10 Submittals

The following will be submitted during installation:

1. Daily records/logs prepared by the installer documenting work performed, personnel involved, general working conditions, and any problems encountered or expected on the project. These records will be submitted on a weekly basis.
2. Copy of subgrade acceptance forms by the installer.
3. QC documentation.

10.4 Post-installation

10.4.1 Final Examination

The RPR will perform a final GCL examination after portions of installation have been completed. The RPR will examine the GCL for the following:

1. Tears or defects
2. Proper overlaps
3. If any portion of the GCL requires repairs based on the above examination, it will be repaired in accordance with the procedures in Subsection 10.3.6.

10.4.2 Submittals

The following will be submitted after installation is completed:

1. Installation certification prepared by the installer certifying that the GCL was installed in substantial accordance with the specifications and the CQA plan.
2. An as-built panel layout diagram prepared by the installer identifying the placement of panels and seams. The numbering sequence will be as agreed upon between the RPR and the installer prior to commencing installation.
3. A copy of the warranty obtained from the manufacturer/installer.

Table 10-1
Summary of Specifications and Quality Control Testing

	PROPERTY	TEST METHOD[5]	UNITS	VALUE	MIN. TESTING FREQUENCY	TESTED BY
Bentonite properties (bentonite removed from finished product)	Free swell Fluid loss	USP-NF-XVII API 13 A	mL/2g mL	24 (MARV) [1] 18 (MAX.A.R.V.)	1/20,000 SF	Manufacturer or independent laboratory hired by the manufacturer
Physical GCL properties	Mass per unit area	ASTM D 5993	lb/sqf	0.75 (MARV)	1/20,000 SF	Manufacturer or independent laboratory hired by the manufacturer
Hydraulic Properties	Flux [2, 3]	ASTM D 5886	m/s	1 x 10^{-8} (MAX)	1/750,000 SF	Manufacturer or independent laboratory hired by the manufacturer

(1) Minimum average roll value (MARV).
(2) Flux is defined as “flow rate/unit area” which can be converted to permeability using the equation: permeability = flux/hydraulic gradient.
(3) Report results at a maximum confining stress of 34 Kpa (5 PSI) and 14 Kpa (2 PSI) head pressure.

Table 10-2
Collection of Field Acceptance Samples

PROPERTY	METHOD	MINIMUM ACCEPTABLE VALUE
Fluid loss	API 13 A	15 mL[1]
Free swell	USP-NF-XVII	24 mL at 24 hours[2]
Liquid limit	ASTM D 4318	500%[2]

(1) Maximum Average Roll Value (Max.A.R.V.)
(2) Minimum Average Roll Value (M.A.R.V.)

Section 11
Geocomposites

A geocomposite will be installed over the barrier layer in the final cover to provide drainage. A geocomposite will also be installed over the composite liner on the 3 (horizontal): 1 (vertical) sideslopes to function as the leachate collection layer. A geocomposite may also be installed above the composite liner on the bottom of the facility in lieu of the Geocushion™ and some of the aggregate fill in the leachate collection layer.

This section is divided into three major subheadings, which cover the QA requirements for pre-installation, installation, and post-installation. The terms pre-installation, installation, and post-installation are applicable only to the geocomposite installation and do not apply to the overall construction.

11.1 Pre-installation

11.1.1 Manufacturing

Material Specifications

Geotextile and geonet suitable for producing the geocomposite to be used in the landfill final cover and leachate collection layer are based on the material specifications of the geotextile and geonet listed in Subsection 7.1.1 and Subsection 9.1.1, respectively.

Quality Control Requirements/Manufacturer's Certification

The geocomposite manufacturer (fabricator) will provide the CQA officer with certification of geotextile and geonet materials used in the fabrication of the geocomposite rolls delivered to the job site. The geocomposite manufacturer will also provide the CQA officer with representative samples of the geotextile used in the fabrication of the geocomposite rolls for conformance testing. Requirements for the manufacturer's certification for geonets are described in Subsection 9.1.1. Requirements for the manufacturer's certification of geotextiles are shown in Table 11-1.

11.1.2 Delivery, Handling, and Storage of Geocomposite Rolls

Each geocomposite roll, for use at the landfill facility, will be marked by the geocomposite manufacturer with the following information and in the following manner:

1. When fabric is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
2. Each roll label will contain the following information at a minimum:
   - Name of manufacturer (or fabricator)
   - Style and type number
   - Roll length and width
   - Batch (or lot) number, if applicable
   - Date of manufacture
   - Direction for unrolling
   - Roll number
3. On the outside of the roll, all lettering should be a minimum of ½ inch high, and on the inside of the core, the lettering should be at least ¼ inch high.

The geocomposite manufacturer will use the following guidelines in packaging, wrapping, and preparing all geocomposite rolls for shipment:

1. When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
2. Cover each roll with a wrapping material that will protect the geotextile from damage due to shipment, water, sunlight, or contaminants.

The following practices should be used as a minimum in receiving and storing geocomposite rolls in the designated storage area at the job site:

1. While unloading or transferring the geocomposite rolls from one location to another, prevent damage to the geocomposite. If practicable, the installer may use forklift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least $^{2}/_{3}$ the length of the rolls to avoid breaking the cores and possibly damaging the geocomposite. Do not drag the rolls.
2. Store the geocomposite rolls to ensure that they are adequately covered to protect the geocomposite from the following:
   - Precipitation

- Ultraviolet radiation, including sunlight
- Strong oxidizing chemicals, acids or bases
- Flames, including welding sparks
- Temperatures in excess of 160°F
- Soiling

The RPR will observe and document throughout the pre-installation, installation, and post-installation periods for observing and documenting that the installer provides adequate handling equipment used for moving geocomposite rolls and that the equipment and handling methods used do not pose unnecessary risk of damage. The installer is responsible for means and methods to implement the work.

The installer will be responsible for ensuring that materials installed meet specifications (*i.e.*, the roll marking label information indicates required specifications and properly represents materials). The RPR will maintain a log of geocomposite roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job site:

1. Date of shipment from geocomposite manufacturer
2. Date of receipt of delivery at job site
3. For each geocomposite roll, the following information will be noted:
   - Roll number
   - Batch (lot) number, if applicable

11.2 Installation

This section describes the QA requirements applicable to the installation and testing of geocomposites. This section includes roll sample testing, installation, observations, and documentation of geocomposites.

11.2.1 Testing Requirements

This subsection describes the test method, including sampling procedures and frequencies, and the role of the Geosynthetic Testing Laboratory in testing the geocomposite roll samples.

Test Method

Unless specified otherwise, all sampling procedures will be performed in accordance with the referenced test method defined in this section.

Geocomposite roll samples will be collected by the RPR. Sample frequency will be based on ASTM D 4354, Procedure A, where the number of units per lot is defined as the number of rolls for a specified lot (using batch or lot numbers) delivered to the job site in one shipment. Required sampling frequencies are shown in Table 8-1.

Samples will be 3 feet long by the full width of the roll and will not include the first 3 feet of any roll. Since machine direction for the geocomposite rolls is the direction that the material comes off the roll, machine direction for any sample will always be along the 3-foot-length dimension of the sample.

Table 11-1 lists the test and the test method to be performed on geocomposite roll samples. The specifications and methods in evaluating the results are discussed below under procedures for determining geocomposite roll test failures.

Results for ply adhesion will be reported for both the machine and cross direction (machine direction will be taken as the direction the geonet is taken off of the rolls).

Role of Testing Laboratory

The Geosynthetic Testing Laboratory will be responsible for performing the test on samples submitted to them as described above. Results of tests performed will be reported to the CQA officer and the RPR.

Retesting of geocomposite rolls for QA purposes, because of failure to meet any or all of the specifications listed below, can only be authorized by the CQA officer.

The geocomposite manufacturer (fabricator) and/or installer may perform their own tests according to the methods and procedures defined in Table 11-1; however, the results will only be applicable to their own QC needs. These results will not be substituted for the QA testing described herein.

Procedures for Determining Geocomposite Roll Test Failures

Table 11-1 lists the accepted values that are applicable to geotextile component the geocomposite. The values in Table 11-1 are based on minimum values.

The following procedure will be used for interpreting results relative to acceptance or rejection of rolls and shipments of geocomposites to the site:

1. Test results for the stated specifications in Table 11-1 will be evaluated in accordance with ASTM D 4759 for determining acceptance of roll shipments.
2. The RPR will coordinate and document the conformance testing and the determination of material acceptance or rejection.

11.2.2 Placement

The installer will install all geocomposites in such a manner as to ensure that they are not damaged in any way and in a manner that complies with the following:

1. On sideslopes, the geocomposites will be securely anchored, then rolled down the slope in such a manner as to continually keep the geocomposite in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles.
2. In the presence of winds, all geocomposites will be secured by suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
3. Cutting should be done according to manufacturer's recommendations.
4. The installer will take necessary precautions to prevent damage to underlying layers during placement of the geocomposite.
5. During placement of geocomposites, care will be taken not to entrap any stones, excessive dust, or moisture that could cause clogging of the drainage system.

11.2.3 Overlaps and Joining

The following requirements will be used with regard to overlapping and joining of geocomposite rolls:

1. Adjacent rolls will be overlapped by a minimum of 4 inches.
2. These overlaps may be secured by tying to each other.
3. Tying can be achieved by strings, plastic fasteners, or polymer braid. Tying devices will be black or brightly colored for easy identification. Metallic devices will not be used in any circumstances.

4. No horizontal joints or overlaps will be allowed on slopes greater than 5 horizontal to 1 vertical (*i.e.*, seams will be along, not across, the slope), except as part of a patch.

11.2.4 Repairs

Any tears or other defects in the geocomposite will be repaired by placing a patch extending a minimum of 2 feet beyond the edges of the hole or tear. The patch will be secured to the original geocomposite by tying every 6 inches. If the tear or other defect width is more than 50 percent of the roll width, the damaged area will be cut out and replaced with new geocomposite material. Tying devices will be as indicated in Subsection 11.2.3. The RPR will examine and document that the repair of any geonets is performed according to the above procedure.

11.3 Post-Installation

11.3.1 Final Examination

The RPR will perform a final geocomposite examination after installation of each geocomposite layer has been completed. The objectives of this step are as follows:

1. Examine for presence of tears or defects
2. Examine overlaps to make certain that they are in conformance with the requirements of Subsection 11.2.3.

If any portion of the geocomposite requires repairs due to the above examination, they will be performed according to the procedures in Subsection 11.2.4.

If there will be an extended time delay between completion of the geocomposite and the start of the installation of any overlying cover, the installer will make provisions by using a temporary covering or other suitable methods, to protect the upper geotextile component against exposure to sunlight and ultraviolet radiation.

11.3.2 Placement of Soil Materials

The construction contractor will place all soil materials located on top of the geocomposite in such a manner as to minimize the following:

1. Damage of the geocomposite
2. Slippage of the geocomposite on underlying layers
3. Excessive tensile stresses imposed on the geocomposite

If portions of the geocomposite are exposed, the RPR will periodically place two (or more, at his discretion) marks on the geocomposite 10 feet apart along the slope and measure the elongation of the geocomposite during the placement of soil.

Table 11-1
Geocomposite Acceptance Specifications

PROPERTY	UNITS	FINAL COVER VALUE	LEACHATE COLLECTION LAYER VALUE	TEST METHOD	TYPE OF CRITERION
Ply Adhesion - Machine Direction	ppi	1.0	1.0	ASTM F904	Minimum
Ply Adhesion - Cross Direction	ppi	1.0	1.0	ASTM F904	Minimum
Geotextile Apparent Opening Size	NA	No. 70	100 – 140	ASTM D 4751	Maximum
Geotextile Grab Strength	lb	200	300	ASTM D 4632	Minimum
Geotextile Grab Strength Elongation	Percent	50	50	ASTM D 4632	Minimum
Geotextile Trapezoidal Tear	lb	65	115	ASTM D 4533	Minimum
Geotextile Puncture Strength	lb	80	175	ASTM D 4833	Minimum
Geotextile Mullen Burst Strength	lb/sq in.	400	580	ASTM D 2210	Minimum
Geocomposite Transmissivity	m^2/sec	1.0×10^{-3} (1)	1.8×10^{-3} (2)	ASTM D 4716	Minimum

(1) Transmissivity of the geocomposite subjected to a load of 10,000 psf and a gradient of 0.1.
(2) Transmissivity of the geocomposite subjected to a load of 15,000 psf and a gradient of 0.1.

Section 12
Select Waste Fill

Select waste fill refers to select ash or waste material that will be placed as a protective layer over the granular drainage material, and on the waste as it approaches final grade to provide a leveling course prior to placement of the final cover.

12.1 Procedures and Observations

The RPR will observe select waste fill placement activities and document relevant observations to support certification of the following requirements:

1. Select waste fill material shall be free of cinders and solid impurities capable of puncturing the GCL or the geomembrane.
2. Select waste fill shall be placed in 8-inch loose depth maximum lifts and compacted with a minimum of two passes of the compaction equipment.
3. The completed select waste fill layer shall have a uniform surface.

12.2 Field and Laboratory Testing

Field and laboratory testing of select waste fill material is not required; however, as discussed in Subsection 12.1 above, the RPR will observe and document the consistency of the fill material and placement procedures.

12.3 Thickness Documentation

The top and bottom of the select waste fill layer will be surveyed on a 50-foot grid pattern. The minimum acceptable compacted thickness will be 12 inches vertical in the liner and 12 inches vertical in the cap.

Section 13
Piping

This section of the CQA plan applies to piping used in the leachate collection and removal system in the landfill liner and in the gas removal system. This section is divided into three major subheadings, which cover the QA requirements for the pre-installation (which includes resin manufacturers, piping manufacturers, and fabricators), installation, and post-installation (which includes the final observation and documentation of piping installations prior to installation of other materials over and around the pipe). These terms pre-installation, installation, and post-installation are applicable only to the piping installation and do not apply to the overall construction.

Individual pipe sizes and SDRs to be used for each individual pipe installation are not detailed in this section; rather, the plans and specifications should be used for the determination of correct size and wall thickness.

13.1 Pre-installation

This section describes the QA measures that are applicable to the PE resin manufacturers, piping manufacturers, piping fabricator used to perforate the pipe, and finished piping delivery to the site, prior to installation.

13.1.1 Manufacturing

Material Specifications

Any pipe used must be made from extra high molecular weight (EHMW) PE resin, and the manufactured piping must be classified as Type III, Class C, Category 5, Grade P34 material according to ASTM D 1248 and also have a cell classification of 345434C as defined by ASTM D 3350. Pipe shall be free of paint or other surface treatments.

Quality Control Requirements

Prior to the delivery of any piping to the site, the piping manufacturer will provide the CQA officer with the following information:

1. The resin supplier, location of supplier's production plant(s) and resin brand name and product number.

2. Any test results obtained by the piping manufacturer and/or the pipe manufacturer's testing laboratories to document the quality of the resin used in manufacturing the piping.
3. The QC plan that the piping manufacturer will be using for the pipe being supplied.

Fabricator

The piping fabricator will be responsible for perforating the pipe, delivered by the piping manufacturer, according to the plans and specifications. The piping fabricator will be responsible for preparing and shipping the perforated pipe to the job site. Marking of the pipe must be performed in accordance with Subsection 13.1.2.

Manufacturer's Certification

The piping manufacturer will provide certification, based on tests performed by either the piping manufacturer's laboratory or other outside laboratory contracted by the piping manufacturer, that the pipe supplied under this plan will meet the following specifications:

1. The finished pipe is classified as Type III, Class C, Category 5, Grade P34 according to the provisions of ASTM D 1248.
2. The finished pipe meets the cell classification of 345434C according to the provisions of ASTM D 3350.
3. The finished pipe has the SDR value specified.

13.1.2 Delivery, Handling, and Storage of Piping

Each bundle of pipe prepared for shipment by the Piping Fabricator will be marked with the following information:

1. Nominal Size
2. Dimension Ratio
3. Pressure Rating
4. Type (manufacturer)
5. Material Classification
6. Certification Bases
7. Blank Position for GRI Use

8. Pipe Test Category
9. Plant
10. Extruder Number
11. Date
12. Operator Number
13. Shift Letter
14. Resin Supplier Code

Example: 10" IPS SDR 15.5 110 psi (Trade Name) PE 3408 ASTM F-714 GRI C3 P5 06FEB89 55A P

The pipe will be protected, during shipment, from excessive heat or cold, puncture, or other damaging or deleterious conditions. The pipe will be stored on site in a manner suitable to protect it from long-term ultraviolet exposure, prior to actual installation.

The RPR will observe and document throughout the preconstruction, construction, and post-construction periods that the installer provides adequate handling equipment for moving pipe and that the equipment and handling methods used do not pose unnecessary risk of damage. The installer is responsible for means and methods to implement the work.

The installer will be responsible for making certain that the manufacturer, type and size of each pipe is correct. The RPR will maintain a log of pipe deliveries throughout the installation. The following information at a minimum will be recorded on the log for each shipment received at the job site:

1. Date of shipment from piping manufacturer
2. Date of receipt of delivery at job site
3. For each pipe, the following information will be noted:
    - Pipe size and type
    - Batch (lot) number

13.2 Installation

This section describes the requirements applicable to pipe installation. This subsection includes installation, observations, and documentation of piping installations.

13.2.1 Pipe Seams

Unless approved otherwise by the CQA officer, all pipe seams will be made by the butt fusion procedure as defined by Phillips Driscopipe, Inc. and Plexco Piping Company. Sections of polyethylene pipe should be joined into continuous lengths on the job site above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. The butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 400°F, alignment, and 75 psi interfacial fusion pressure. Butt fusion joining shall be 100 percent efficient offering a joint weld strength equal to or greater than the tensile strength of the pipe. Socket fusion shall not be used. Extrusion welding or hot gas welding of HDPE shall not be used for pressure pipe applications nor in fabrications where shear or structural strength is important. Flanges, unions, grooved-couplers, transition fittings, and some mechanical couplers may be used to mechanically connect HDPE pipe without butt fusion. Refer to the manufacturer's recommendations. The following procedures will be used regarding butt fusion seams:

1. Seams should be made at the pipe manufacturer's recommended heater plate temperature of approximately 400°F for fusing pipe and fittings.
2. For pipe diameter sizes 4 inches (nominal) and larger seams will be made using the hydraulic fusion machines. For pipe diameters of less than 4 inches, manual fusion equipment can be used.
3. Care will be taken to make certain that adequate pressures are used for fusing pipes and that sufficient cooling periods are allowed prior to testing, bending, or backfilling of pipe sections.

13.2.2 Placement Requirements

Pipe placement will be done in accordance with the following procedures and requirements:

1. Piping placement will not be performed in the presence of excessive moisture. The RPR will document that this condition is fulfilled. Additionally, the RPR will document that the supporting backfill has not been damaged by weather conditions. The RPR will inform the CQA officer if any of the above conditions are not fulfilled for evaluation of the necessity of corrective action.
2. The prepared surface underlying the piping has not deteriorated since previous acceptance, and it is still acceptable immediately prior to piping placement.
3. Method used to place the piping does not cause damage to the piping and does not disturb the supporting backfill.

4. The RPR will observe and document all pipe installation. Deviations from the plans and specifications will be brought to the attention of the CQA officer for evaluation of the necessity of corrective action.
5. The RPR will observe and document the placement of geotextile filter to line the trenches and placement of pipe bedding stone around collector pipes according to the plans and specifications and the procedures described in Subsection 7.2.1.
6. Observations and measurements should be made to ensure that the pipes are the specified size, manufactured of the specified material, and that pipe perforations are sized and spaced as specified.
7. All piping should be located as noted in the plans and specifications. Locations, grades, and size requirements are specified on the details of the plan set. Observations and surveying measurements should be made to ensure the pipes are placed at the specified locations and grades, and in the specified configuration. Observations should be made throughout the construction to ensure that backfilling is completed as specified in the plans and specifications and that, in the process, the pipe network is not damaged.

13.2.3 Pipe Boots

Pipe boots shall be installed as shown on approved shop drawings with a continuous extrusion weld joining the pipe to the geomembrane liner. The RPR shall observe all pipe boot installations.

13.2.4 Damages

The RPR will examine each pipe after placement for damage. Damaged pipes or portions of pipes that have been rejected will be marked and removed from the installation area and documented by the RPR.

13.3 Post-Installation

Pipe inverts (or top of pipe elevations) and coordinate locations shall be surveyed at 50-foot intervals and at all tee connection locations. Additional surveying requirements regarding granular soil backfill placement are discussed in Subsection 6.3.

Section 14
Compacted Prepared Subgrade Fill

Prepared subgrade fill refers to the 1-foot thick compacted subgrade soil beneath the composite liner with permeability of 4.2×10^{-4} cm/s or less. The existing on-site subgrade soils if appropriate and soil from the owner's on-site borrow source are proposed for the prepared fill subgrade layer. Existing soil data, cross sections, and borrow investigation reports will be made available to the contractor.

14.1 Procedures and Observation

The installer will be responsible for means and methods to implement the work. The RPR will observe the compacted prepared subgrade construction activities and will document relevant observations to support certification of the following requirements:

1. The RPR will confirm the uniformity of the prepared subgrade fill. Soil excavation, proportioning, mixing, and placement will be monitored for segregation and removal of unsuitable material and for changes in soil type, color, texture, and moisture content.
2. The construction contractor will segregate and/or remove unsuitable materials such as soils not meeting acceptance criteria (boulders, cobbles, and organic material).
3. The RPR will measure field densities and moisture contents, using methods described in Subsection 14.2 (Sampling Requirements and Acceptance Criteria), to document that the compacted prepared subgrade is in substantial conformance with the placement specifications and that soil placement has been conducted in a manner to achieve a uniform, homogeneous mass meeting the permeability requirement.
4. Voids created by nuclear density gauge testing or retrieval of Shelby tube samples will be backfilled with sodium bentonite.
5. The prepared subgrade fill shall be placed in two loose lift thicknesses not exceeding 8 inches. Each loose lift shall be compacted with multiple passes using appropriate compaction equipment. If the soil is deposited in thickness exceeding 8 inches, dozers will be used to spread the soil to an 8-inch thickness prior to compaction. This will ensure adequate reduction of clod size and provide a thin layer to achieve required compaction throughout the lift.
6. Areas of unacceptable hydraulic conductivity, compaction density, or moisture content, as defined by Subsection 14.2 (Sampling Requirements and Acceptance Criteria), will be documented by the RPR. Corrective action will consist of moisture conditioning of the soil or additional compactive effort as necessary. Methods for moisture-conditioning soils are described in Item 7 below. Following corrective actions, such areas will be retested.

7. If necessary, surfaces of the prepared subgrade to receive successive lifts of prepared subgrade fill will be moisture-conditioned either by scarification and addition of water where desiccated, or by disking and air drying where saturated to promote effective bonding of lifts. Following scarification, water will be applied with a spray bar applicator or equivalent methods to achieve uniform distribution.
8. Soil compaction will be performed in a manner to achieve continuous and complete keying together of the prepared subgrade construction areas. Stepped joints will be utilized to connect lateral segments of the prepared subgrade construction.
9. No frozen soils will be used for prepared subgrade construction. Frozen soils in the compaction work area will be removed.
10. Stones that are larger than 0.5-inch in diameter shall be removed from the surface of the final lift of the prepared subgrade to avoid potential for puncturing the geosynthetic clay liner. The method to detect and remove stones requires an initial overfill of compacted prepared subgrade soils approximately 1 inch above design grades. A grader will then blade the prepared subgrade surface to obtain uniform subgrades and design elevations. Stones present will be exposed and loosened by the grading. The RPR shall inspect the prepared subgrade during this process and document removal of stones by the contractor. Voids made by removal of stones shall be filled with prepared subgrade soil, and then the entire prepared subgrade surface shall be rolled with a smooth drum compactor.
11. The prepared subgrade surface on which the composite liner will be placed shall be maintained in a firm, clean, and smooth condition, free of standing water, during liner installation.
12. Preconstruction planning will be undertaken to sequence construction activities to minimize the length of time any completed prepared subgrade surfaces are exposed prior to receiving protective cover. Protective cover will be provided by installation of the geosynthetic clay liner and the geomembrane.
13. Preconstruction planning will be undertaken to minimize the need for traffic over the completed prepared subgrade surface. Heavy trucking of materials (ingress or egress) and cleated equipment will not be allowed directly on completed prepared subgrade surfaces. If this is unavoidable, an evaluation will be made upon termination of the haul route to determine if the prepared subgrade should be reconstructed or repaired in such areas. Flotation-type all-terrain vehicles will be used to assist in deployment of the geosynthetic clay liner to avoid disruption of the completed prepared subgrade surface.

14.2 Sampling Requirements and Acceptance Criteria

Field and laboratory sampling frequencies are based on proportionate sampling of construction areas or volume of material placed as specified below. This section describes required analysis, methods, sample frequency, and acceptance limits. Table 14-1 summarizes the minimum QA testing recommended in Subsection 14.3. The RPR will perform field tests and collect soil samples for laboratory analysis.

14.3 Field Testing and Sampling

The following field testing and sampling methods and frequencies will be used by the RPR during construction of the prepared subgrade.

- One field density and as-placed moisture content test (ASTM D 3017 and ASTM D 2922 Method B) will be performed for each compacted lift on an approximate 100-foot grid pattern.
- Initially, a representative (grab) soil sample of the prepared subgrade soils will be collected from the borrow source and submitted to the Soils Testing Laboratory for testing described in Subsection 14.3.4. Additional samples will be collected every 4,000 cy for each major soil type utilized. A sample will also be collected when changes in the physical appearance or soil characteristics are observed.
- A minimum of one undisturbed Shelby tube sample will be obtained for each acre or less for every lift of prepared subgrade placed. Samples will be submitted to the Soils Testing Laboratory for testing described in Subsection 14.3.3.
- At a minimum, at least one field density/moisture content test will be conducted per lift and at least one test per day of compacted prepared subgrade construction.

A NDG may be used for field moisture and density determination. The calibration of NDGs used for documentation shall be initially checked and adjusted (if necessary) according to the manufacturer's guidelines. Initial calibration of the NDG shall be made with one of the alternate test methods identified in Construction Specifications for determining field density and moisture content.

14.3.1 Field Testing Acceptance Criteria

Acceptance criteria for field density will require soil compaction to a minimum of 95 percent of the Standard Proctor (ASTM D 698) maximum dry density. Specific moisture content requirements will be identified in the construction specifications. The acceptable range will be based on Proctor moisture-density relationships and compaction versus permeability relationships.

14.3.2 Laboratory Testing

Routine laboratory testing of the compacted prepared subgrade soils will be performed on samples from the borrow area or samples from the disking operation and on the in-place soils collected by the RPR. Samples for determining in-place properties will be collected by pushing Shelby tubes. Soil characteristics will be determined from representative samples and from Shelby tube samples.

14.3.3 Undisturbed Sample Analysis

The following analysis will be performed on ***all*** undisturbed samples obtained:

PARAMETER	TEST METHOD
Hydraulic Conductivity	ASTM D 5084 or SW 846-USEPA Method 9100
Moisture Content and Dry Density	ASTM D 2216
Atterberg Limits	ASTM D 4318
Grain-size Analysis (P200)	ASTM D 422 (1)

(1) Percentage of soil finer than the No. 200 sieve (*i.e.*, soil finer than 0.075 mm).

14.3.4 Representative Sample Analysis

The following laboratory analyses will be performed on ***all*** representative samples obtained, except where noted:

PARAMETER	TEST METHOD
Moisture-Density Relationship using Standard Proctor Compaction	ASTM D 698 (1, 2)
Atterberg Limits	ASTM D 4318
Grain-size Analysis (sieve and hydrometer)	ASTM D 422 (3)
Moisture Content	ASTM D 2216
Hydraulic Conductivity (4)	ASTM D 5084 or SW 846-USEPA Method 9100

(1) A five-point Proctor analysis is required for first and second sampling criteria.
(2) A one-point Proctor analysis may be utilized for representative samples collected for the third sampling criteria (apparent changes in soil quality) to verify applicability of previously analyzed moisture-density relationships. If the result does not verify applicability, a five-point analysis will be performed in accordance with the first sampling criteria.
(3) Distribution shall be reported through the 0.002-mm particle size.
(4) For every 8,000 cy of soil extracted from the borrow source, perform one hydraulic conductivity test. The hydraulic conductivity test will be run on a sample of soil remolded to 95 percent of its Standard Proctor (ASTM D 698) maximum dry density at 2 percent over its optimum moisture content.

14.3.5 Laboratory Testing Acceptance Criteria

- A saturated hydraulic conductivity of 4.2×10^{-4} cm/s or less

14.4 Thickness Documentation

The top of the prepared subgrade layer will be surveyed at a minimum on the same 50-foot grid pattern as other locations surveyed for bottom of the prepared subgrade layers. Prepared subgrade thicknesses at slope breaks will be surveyed. The prepared subgrade thickness will be determined at surveyed locations and reported in table fashion. The minimum acceptable prepared subgrade liner thickness will be 1-foot vertical to the bottom. The location and elevation of samples requiring surveying will be recorded.