RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services

February 3, 2010

Permit No.	Date	Document ID No.
42-04	**February 05, 2010**	**9562**

Mr. Ming-Tai Chao, P.E.
Environmental Engineer II
NC DENR - Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, NC 27605

RECEIVED
February 4, 2010 via hand delivery
Solid Waste Section
Raleigh Central Office

Re: Halifax County C&D Landfill (Permit No. 42-04)
Permit Application for Area 1 Continued Operations
Response to Comments

Dear Mr. Chao:

On behalf of Halifax County, Richardson Smith Gardner & Associates, Inc. (RSG) would like to the comments in your letter dated October 2, 2009 (see **attached**), as follows. The comments stated in your letter are repeated below in *italics* and our response follows in **bold**.

Attachment A – Facility and Engineering Plan

1. *(Section 5.1 Final Cover System) The Solid Waste Section has significant concerns regarding the response to Comment 4 dated December 22, 2008. The 22 September 2009 response stated that "based on the test results from the MSW landfill closure the average hydraulic conductivity (permeability) of the soil cover under the C&D landfill area is 2.8 x 10^{-7} cm/sec (results of 15P, 41P, 45P, and 49P)." Pursuant to Rule .01627(c)(1)(A), the proposed final soil cover for the C&D landfill must have a permeability less than or equal to 2.8 x 10^{-7} cm/sec. The DWM may approve an alternative final cover system which has a permeability less than or equal to 2.8 x 10^{-7} cm/sec. In addition to revise the Section 5.1, please also revise other related sections (contexts and figures) including Technical Specification, Closure Plan, and the cost estimate for closure in the permit application.*

The use of a <u>minimum</u> hydraulic conductivity (permeability) value equal to the <u>average</u> previously achieved in the cover for the underlying MSW landfill is problematic. In that the available soils are believed to be similar to that used in the previous closure, there would be a high probability of failing test results without increased compaction effort (difficult to achieve over waste) and/or bentonite amendment. Thus, the proposed final cover has been modified such that the flatter top areas will be closed with a geomembrane or GCL barrier layer and the side slopes will be closed with soil. This alternative final cover system is demonstrated to have an improved performance over the regulatory final cover system assuming a permeability of 2.8 x 10^{-7} cm/sec (see revised Facility and Engineering Plan). The components of the proposed final cover system will consist of the following components (top-down):

<u>Alternative Final Cover System (.1627 (c) (2)):</u>

<u>Top Slopes (Typically 5 to 10%):</u>

- **an 18-inch thick vegetative soil layer;**

- **a drainage geocomposite;**
- **a 30-mil textured LLDPE geomembrane or geosynthetic clay liner (GCL); and**
- **a 12-inch thick intermediate cover layer.**

Side Slopes (4H:1V):

- **a 24-inch thick vegetative soil layer.**

Please find attached the following revised documents, which have been updated to reflect the proposed final cover system:

- **Executive Summary;**
- **Facility and Engineering Plan;**
- **Technical Specifications;**
- **CQA Manual;**
- **Closure and Post-Closure Plan; and**
- **Permit Drawings (All sheets revised).**

Note that in order to provide a larger area for the top slopes, which will incorporate a geomembrane or GCL, the proposed fill grades have been modified by reducing the top elevation to approximately 358 and pushing out the southern slope slightly to recoup the fill volume lost by lowering the top elevation (The previously reported gross elevation remains unchanged.).

2. *Please add locations of the monitoring wells G-13, G-13D, MW-17, MW-18S, and MW-18D to Figure 1. Additionally, please have a professional engineer sign and stamp the Figure 1.*

Figure 1, which is part of the Operations Manual, has been revised accordingly. Please see the attached revised Operations Manual.

3. *(Section 5.2 & Attachment E) Please provide a copy of the approval letter of the Erosion and Sediment Control Plan appended to the Attachment E.*

Once these responses to comments have been accepted by the Solid Waste Section, the erosion and sediment control plan will be submitted by the County to Land Quality for approval.

Attachment D – Operations Plan

4. *(Section 2.4.2 on page 2.0-4) Please provide the waste screening forms in Appendix B.*

Reference should have been made to the waste screening form provided in Appendix "A". Section 2.4.2 has been revised accordingly. Please find attached a revised copy of the Operations Manual.

Attachment F – Closure and Post-Closure Plan

5. *(Figure D1) Please correct the permeability value of the proposed compacted soil barrier according to Section 5.1 in Attachment A (also see Comment 1).*

   Per the response to Comment 1, the attached Closure and Post-Closure Plan has been revised to reflect the proposed alternative final cover system. Relevant permit drawings, including Drawing D1, have also been revised and are attached.

6. *(Section 1.2) The conversion factor of 0.5 ton/cubic yard waste is inconsistent with the one used to calculated landfill capacity described in Section 3.2, Attachment A. Please clarify.*

   The conversion factor should have been listed as "0.7" tons/cubic yard. Section 1.2 of the revised Closure and Post-Closure Plan has been revised accordingly.

Please contact me at your earliest convenience with any questions or comments which you may have on this submittal or any further questions or comments you may have on this application.

Sincerely,
Richardson Smith Gardner & Associates, Inc.

Pieter K. Scheer, P.E.
Principal, Project Manager
pieter@rsgengineers.com

Attachments: NC DWM Letter - October 2, 2009
Revised Executive Summary
Revised Facility & Engineering Plan
Revised Technical Specifications
Revised CQA Manual
Revised Operations Manual
Revised Closure and Post-Closure Plan
Revised Erosion and Sedimentation Control Plan
Revised Drawings

cc: Larry Garriss, Halifax County

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North Carolina Department of Environment and Natural Resources
Division of Waste Management

Beverly Eaves Perdue
Governor

Dexter R. Matthews
Director

Dee Freeman
Secretary

Solid Waste Section

October 2, 2009

Mr. Larry Garriss, Solid Waste Director
Halifax County Department of Public Utilities
P.O. Box 70
Halifax, North Carolina 27839

Re: Additional Comments on Permit Application of Halifax County Construction and Demolition Debris Landfill (C&DLF), Area 1 Continued Operations (the Permit Application), Halifax County, North Carolina
Permit No. 42-04, Document ID No. 8703

Dear Mr. Garriss:

On September 24, 2009, the Solid Waste Section of the Division of Waste Management (DWM) received the written responses to the DWM's comment dated December 22, 2008. Richardson Smith Gardner and Associates (RSG), on behalf of Halifax County, prepared and submitted the responses (DIN 8696) which have been incorporated to the revised Permit Application. The Solid Waste Section has preformed a review of the above-referenced documentations and requests for additional information below:

Attachment A – Facility and Engineering Plan

1. (Section 5.1 Final Cover System) The Solid Waste Section has significant concerns regarding the response to Comment 4 dated December 22, 2008. The 22 September 2009 response stated that "based on the test results from the MSW landfill closure the average hydraulic conductivity (permeability) of the soil cover under the C&D landfill area is 2.8×10^{-7} cm/sec (results of 15P, 41P, 45P, and 49P)." To pursuant the Rule .01627(c)(1)(A), the proposed final soil cover for the C&D landfill must have a permeability less than or equal to 2.8×10^{-7} cm/sec. The DWM may approve an alternative final cover system which has a permeability less than or equal to 2.8×10^{-7} cm/sec. In addition to revise the Section 5.1, please also revise other related sections (contexts and figures) including Technical Specification, Closure Plan, and the cost estimate for closure in the permit application.

2. Please add locations of the monitoring wells G-13, G-13D, MW-17, MW-18S, and MW-18D to Figure 1. Additionally, please have a professional engineer sign and stamp the Figure 1.

3. (Section 5.2 & Attachment E) Please provide a copy of the approval letter of the Erosion and Sediment Control Plan appended to the Attachment E.

Attachment D – Operations Plan

4. (Section 2.4.2 on page 2.0-4) Please provide the waste screening forms in Appendix B.

Attachment F – Closure and Post-Closure Plan

5. (Figure D1) Please correct the permeability value of the proposed compacted soil barrier according to Section 5.1 in Attachment A (also see Comment 1).

6. (Section 1.2) The conversion factor of 0.5 ton/cubic yard waste is inconsistent with the one used to calculated landfill capacity described in Section 3.2, Attachment A. Please clarify.

Please incorporate the requested information and associated documents, revisions, and responses to a new hard copy and an electronic copy of the revised permit application. The Solid Waste Section appreciates your efforts and cooperation in this matter. If you have any questions, please contact me at (919) 508- 8507.

Sincerely,

Ming-Tai Chao, P.E.
Environmental Engineer II
Permitting Branch, Solid Waste Section

cc:
Pieter K. Scheer, P.E., RSG
Donna Wilson, DWM
Dennis Shackelford, DWM
Central Files
Ed Mussler, Permitting Branch Supervisor
Zinith Barbee, DWM
Mary Whaley, DWM

EXECUTIVE SUMMARY

GENERAL

The following is a Permit Application submitted on behalf of Halifax County, North Carolina for the continued operations of the Area 1 construction and demolition debris (C&D) disposal unit at the County's existing landfill facility located near Littleton (Permit 42-04). This disposal unit is a vertical expansion of a closed unlined municipal solid waste (MSW) landfill unit. This permit application has been prepared to satisfy the requirements of Rule 15A NCAC 13B.0547 of the North Carolina Solid Waste Management Rules.

The Area 1 disposal unit occupies approximately 6.5 acres (waste footprint) of the closed MSW landfill footprint (total waste footprint is approximately 24 acres). At the projected gate rates as described in the Facility and Engineering Plan (**Attachment A**), Area 1 is projected to provide disposal capacity until late 2012.

The design of the final cover system for the Area 1 landfill unit will use an alternative final cover system, as allowed under North Carolina regulations. The equivalency of the proposed alternative final cover system to the regulatory specified final cover system is demonstrated in the Facility and Engineering Plan (**Attachment A**). The components of the final cover system will consist of the following components (top-down):

Alternative Final Cover System (.1627 (c) (2)):

Top Slopes (Typically 5 to 10%):

- an 18-inch thick vegetative soil layer;
- a drainage geocomposite (with drainage breaks);
- a 30-mil textured LLDPE geomembrane or geosynthetic clay liner (GCL); and
- a 12-inch thick intermediate cover layer.

Side Slopes (Typically 4H:1V):

- a 24-inch thick vegetative soil layer.

This submittal also presents the proposed plan for future development of the Area 2 disposal unit. The proposed Area 2 will occupy approximately 6 acres (waste footprint) to the east of the Area 1 disposal unit. At the projected gate rates, Area 2 has been designed for approximately 14 years of disposal volume. This submittal also presents the phasing of Area 2 which delineates each $\pm$ 5-year development sequence. A separate permit application for Area 2 was previously submitted to the North Carolina Department of Environment and Natural Resources (DENR) Division of Waste Management (DWM) for review.

REGULATORY REFERENCES

This submittal has been prepared in accordance with the requirements of the North Carolina Solid Waste Management Rules (15A NCAC 13B) and the North Carolina Sedimentation Control Rules (15A NCAC 4), which are enforced by the Division of Waste Management (DWM) and the Division of Land Quality, respectively, of the North Carolina Department of Environment and Natural Resources (DENR). Included in this submittal are the following documents *(with applicable rule(s) in italics)*:

Facility and Engineering Plan *(13B.0537 and .0539)*;
Technical Specifications *(13B.0539)*;
Construction Quality Assurance (CQA) Manual *(13B.0541)*;
Operations Manual *(13B.0542)*;
Closure and Post-Closure Plan *(13B.1627 and .1629)*;
Erosion and Sedimentation Control Plan *(13B.0540 and 15A NCAC 4)*;
Permit Drawings *(13B.0537, .0539, .0540, .0542, .1629, and 15A NCAC 4)*;
Corrective Action Plan *(13B.1635, .1636, and .1637)*;
Financial Assurance *(13B.1628)*;
Local Government Approval *(13B.0536)*.

Facility and Engineering Plan

Halifax County C&D Landfill
Area 1 Continued Operations
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

June 2008
Revised: January 2010

RICHARDSON SMITH GARDNER & ASSOCIATES
ENGINEERING & GEOLOGICAL SERVICES

14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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HALIFAX COUNTY C&D LANDFILL
AREA 1 CONTINUED OPERATIONS

FACILITY AND ENGINEERING PLAN

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HALIFAX COUNTY C&D LANDFILL
AREA 1 CONTINUED OPERATIONS

FACILITY AND ENGINEERING PLAN

1.0 OVERVIEW

Halifax County, North Carolina currently owns and operates a landfill facility on Liles Road near Littleton. Access for the facility is and will continue to be off of Liles Road. The landfill is permitted under NC Permit 42-04 for the disposal of construction and demolition debris (C&D) waste and the disposal of coal combustion by-products in separate disposal areas. The County also conducts several other solid waste management activities at the facility. Refer to **Drawing S1** (Existing Conditions) (**Attachment G**) which shows the existing conditions and **Section 2.1**, which describes facility services.

The County has operated the landfill under the current permit since 1981. From 1981 through December 1997, the landfill was permitted to receive municipal solid waste (MSW). The MSW was disposed of in one unlined disposal unit (see **Drawing S1**). It is estimated that approximately 900,000 tons of MSW was disposed of in the landfill, which has a total waste footprint of approximately 24 acres. The MSW unit was closed in accordance with applicable State Solid Waste Management Rules.

Beginning in January 1998, and in accordance with State solid waste rules, MSW was no longer disposed of in the landfill. The landfill has continued to operate since 1997 as a C&D landfill (Area 1 disposal unit). The Area 1 C&D disposal unit is a vertical expansion over the MSW disposal unit and has a waste footprint of approximately 6.5 acres. Previously permitted[1] grades for Area 1 are shown on **Drawing S2** (Area 1 Permitted Intermediate Cover Grades). Note that the County plans to limit the footprint of Area 1 by expanding vertically within the existing footprint as shown on **Drawing S3** (C&D Landfill Development Plan).

As Area 1 nears capacity, the County plans to develop the Area 2 disposal unit at the facility (also shown on **Drawing S3**).

This plan presents information describing the continued operations of the Area 1 disposal unit.

2.0 FACILITY SERVICES AND WASTE STREAM

2.1 Facility Services

Currently, the following activities or services are provided at the Halifax County landfill facility:

---

[1]Halifax County Landfill, Request for Permit Extension (Permit No. 42-04), C&D Landfill Vertical Expansion, Letter prepared by G.N. Richardson & Associates, Inc. dated December 23, 2003 (approved by the NC DWM on December 22, 2006).

- Scales and scale house facilities
- Administrative office and maintenance building
- Area 1 C&D Landfill Unit (vertical expansion over closed unlined MSW unit);
- Area 2 C&D Landfill Unit (Proposed);
- Ash Monofill;
- Animal Waste Disposal Area;
- Wood Waste Processing Area;
- White Goods Handling Area;
- Used Tire Storage Area; and
- Used Pesticide Container Storage Area.

2.2 Types of Waste

C&D waste, white goods, tires, yard waste, and used pesticide containers are accepted at the Halifax County landfill facility. The facility also has an ash monofill disposal unit for disposal of wastes from a local coal-fired power plant. Wastes are routed to the appropriate disposal unit or handling area.

2.3 Disposal Rate

An average of between 4,000 to 8,000 tons per year of C&D waste (average of 14 to 29 tons per day based on 280 days of operation per year) is currently accepted at the Halifax County facility, which is currently disposed of within the existing Area 1 landfill unit. The County proposes to dispose of a maximum of 20,000 tons per year of C&D waste (average of 54 tons per day based on 280 days of operation per year). The amount of waste disposed in the ash monofill has varied greatly but is generally less than 10,000 tons per year (average of 36 tons per day based on 280 days of operation per year). Actual annual and daily amounts of both C&D waste and coal combustion by-products are expected to vary considerably.

2.4 Service Area

The landfill facility serves Halifax County.

2.5 Procedures for Waste Segregation

A brief description of procedures for waste segregation is as follows.

Wastes are segregated at the scales. Operators at the scale house are trained to classify and segregate the waste stream. C&D wastes are directed toward the active C&D landfill unit. Ash and related wastes are directed toward the ash monofill. White goods, tires, yard wastes, and pesticide containers are routed to the appropriate processing area. Any waste determined to be municipal solid waste (MSW) is routed toward the Waste Industries transfer station in Weldon or one of the County's convenience sites.

Employees at the landfill are trained in the safety procedures for the handling and detection of illegal waste. The screening of unacceptable waste is done through the random checking of incoming loads by a County employee at the scale house and at the tipping area. When unacceptable waste is detected at the scale house, the load is rejected and not permitted into the facility. If hazardous waste is found at the tipping area, identification of the truck or persons is made (if possible) and documented, then the hazardous waste is identified and placed in a hazardous waste container and taken to a designated hazardous waste staging area for proper disposal. If this occurs, the event is reported to the appropriate authorities.

2.6 Equipment Requirements

The County will maintain on-site equipment required to perform the necessary landfill activities. The County currently uses a Terex 370 compactor in their day to day operation of the C&D landfill unit. Periodic maintenance of all landfilling equipment, and minor and major repair work will be performed in the landfill's maintenance building.

3.0 LANDFILL CAPACITY

3.1 Total Operating Capacity and Life Expectancy

Drawing S3 (C&D Landfill Development Plan), identifies the proposed final configuration for the Area 1 and Area 2 C&D landfill units. The exterior side slopes will be at a 4H to 1V slope and the top elevation will be at approximately 358 feet (Area 1) and 348 feet (Area 2).

The estimated total gross operating capacity, net capacity (accounts for periodic and final cover), disposal area, and life expectancy for Areas 1 and 2 are shown in **Table 1**.

3.2 In-Place Ratio of Waste to Soil and Compaction Factor

The capacities obtained above were based on a 10 percent periodic cover ratio and an estimated compaction factor of 1,400 pounds per cubic yard (pcy) (0.70 tons/cy) for Area 1 and 1,200 pounds pcy (0.6 tons/cy) for Area 2. The higher value was assumed for Area 1 to reflect the compressibility of the existing waste beneath the Area 1 landfill unit. The assumed periodic cover ratio is typical for C&D landfills.

4.0 AVAILABLE SOIL RESOURCES AND REQUIRED SOIL QUANTITIES

The soils required to construct the proposed landfill will be removed from on-site borrow sources.

4.1 Periodic Cover

Assuming the previously mentioned periodic cover ratio of 10 percent, the estimated

quantity of soil that will be required for use as periodic cover during C&D landfill operations is shown in **Table 2**.

4.2 Vegetative Soil Layer

On the basis of an average 2-foot thickness of the vegetative soil layer of the C&D landfill final cover, the estimated in-place volume required is shown in **Table 2**.

4.3 Soil Summary

The above soil quantities are summarized in **Table 2**. The existing borrow area along with the excess excavation from construction of Area 2 is anticipated to have an adequate supply of soil to meet the expected needs.

5.0 CONTAINMENT AND ENVIRONMENTAL CONTROL SYSTEMS

Technical specifications and a project construction quality assurance (CQA) manual for the following materials can be found in **Attachments B and C**, respectively.

5.1 Final Cover System

The components of the Area 1 final cover system will consist of the following components (top-down):

Alternative Final Cover System (.1627 (c) (2)):

Top Slopes (Typically 5 to 10%):

- an 18-inch thick vegetative soil layer;
- a drainage geocomposite (with drainage breaks);
- a 30-mil textured LLDPE geomembrane or geosynthetic clay liner (GCL); and
- a 12-inch thick intermediate cover layer.

Side Slopes (Typically 4H:1V):

- a 24-inch thick vegetative soil layer.

The final cover system will be placed on prepared intermediate cover at a maximum slope of 4H:1V (minimum slopes will be 5%). A landfill gas (LFG) control system and surface water control devices will also be incorporated into the final cover. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications.

A final cover infiltration analysis was performed to demonstrate that the proposed final

cover system allows less overall infiltration than the regulatory final cover system (see **Appendix A**). Note that this permit application assumes the installation of the proposed alternative final cover system.

5.2 Erosion and Sedimentation Control

The Erosion and Sedimentation Control structures provided will be designed and maintained to manage the run-off generated by the 24-hour, 25-year storm event, and conform to the requirements of the Sedimentation Pollution Control Law (15A, NCAC, 4).

A detailed discussion of site erosion and sedimentation control for Area 1 can be found in the Project Erosion and Sedimentation Control Plan (**Attachment E**).

5.3 Landfill Gas Control

In that this C&D landfill overlies a closed MSW landfill unit, a landfill gas (LFG) control system consisting of vents and/or wells will be incorporated into the final cover.

5.4 Access and Roadways

Site operations will provide for all-weather access to active areas and site monitoring locations.

6.0 SLOPE STABILITY

The slope stability of the waste mass is addressed in **Appendix A**. The results of the slope stability analysis indicates that the proposed C&D landfill configuration is stable.

TABLE 1
SUMMARY OF LANDFILL CAPACITY AND LIFE EXPECTANCY

Unit	Area (Ac.)	Capacity (See Note 1)		Life Expectancy (Years)
		Gross (CY)	Net (CY/Tons)	
Area 1 (Filled) (as of May 1, 2008)	6.5	67,399	60,659 CY 51,616 Tons	-----
Area 1 (Remaining)	-----	63,868	33,886 CY 23,720 Tons	4.3 (See Note 2)
Area 2 - Phase 1	3.3	73,129	65,816 CY 39,490 Tons	5.3
Area 2 - Phase 2	2.4	90,571	74,980 CY 44,988 Tons	6.0
Area 2 - Phase 3	-----	102,568	74,016 CY 44,410 Tons	5.9
Totals:	12.2	397,535	309,357 CY 204,224 Tons	21.5

Notes:

1. The net capacity is based on an assumed 10% periodic cover soil ratio and waste density of 0.7 tons/CY (Area 1) and 0.6 tons/CY (Area 2).
2. Area 1 life expectancy is based on an assumed average disposal rate of 5,500 tons/year and is projected from May 1, 2008.
3. Area 2 life expectancy is based on an assumed average disposal rate of 7,500 tons/year.

TABLE 2
SOIL SUMMARY

Material	Quantity (CY)				
	Area 1 (See Note 1)	Area 2 - Phase 1	Area 2 - Phase 2	Area 2 - Phase 3	Total
Excavation	-----	81,145	-----	-----	81,145
Structural Fill	-----	(8,644)	-----	-----	(8,644)
Periodic Cover	(3,765)	(7,313)	(8,331)	(8,224)	(27,633)
Final Cover	(26,217)	-----	(7,260)	(20,328)	(53,805)
Totals:	(29,982)	65,188	(15,591)	(28,552)	(8,937)

Notes:

1. Area 1 volumes estimated from May 1, 2008.

Appendix A

Landfill Design Calculations

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HALIFAX COUNTY C&D LANDFILL
AREA 1 CONTINUED OPERATIONS

FACILITY AND ENGINEERING PLAN
APPENDIX A: LANDFILL DESIGN CALCULATIONS

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1.0 Landfill Volume Study (Density & Life Calcs.) ***(Rev. - 1/10)***
2.0 Earthwork Quantities ***(Rev. - 1/10)***
3.0 Slope Stability Evaluation*
4.0 Final Cover Infiltration Analysis ***(New - 1/10)***

* Note that the original slope stability evaluation is conservative considering a lower top elevation in the present submittal. Thus, no change was made to the original evaluation.

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PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Capacity Evaluation (Density & Life Calcs.)

SHEET 1 OF 9
JOB NO. HALIFAX-08-1
DATE 1/29/10
COMPUTED BY PKS
CHECKED BY

Objective

To determine the capacity of landfill units. Also, to estimate the expected life of the landfill unit(s) given the proposed contours and the anticipated waste loading rate(s). As part of the evaluation, an evaluation or estimate of waste density will be required based on the known or assumed percentage of periodic cover soil.

Analysis

The volume(s) will be calculated by using AutoCAD. Alternatively, the volume(s) will be calculated by taking cross sections of the landfill, using a planimeter to measure the area of the cross sections, and using the average end area method.

CAPACITY LF DENSITY & LIFE.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 2 / 9
JOB #: HALIFAX-08-1
DATE: 8/27/09
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Capacity Evaluation - Area 1 Filled (Through May 1, 2008)

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,702	(Estimated based on Volume and Tonnage Estimates)
Waste Density (tcy) =	0.85	
Percentage of Periodic Cover =	10	(Assumed)

Volume Calculations:

Volume of Waste and Periodic Cover (Gross Capacity) Used (cy) =	67,399	(Jan. 1, 1998 - May 1, 2008 - CAD)
Volume of Periodic Cover Used (cy) =	(6,740)	
Net (Waste) Capacity Used (cy) =	60,659	
Net (Waste) Capacity Used (tons) =	51,616	Per NC DWM Records Through FY 2007-08 as Estimated Through May 1, 2008.

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 3 / 9
JOB #: HALIFAX-08-1
DATE: 1/29/10
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Capacity Evaluation - Area 1 Remaining

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,400	(Conservative based on Current Estimates)
Waste Density (tcy) =	0.70	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) = 63,868 (May 1, 2008 Topo. to Top of Final Cover - CAD)

Sum = 63,868 **(= Gross Remaining Capacity)**

Net (Waste) Capacity:

Adjustment For Other Layers:

Area of Final Cover (Ac.) = 6.5

2.5 feet (Avg) Final Cover = (26,217) cy

Sum = (26,217) cy

Volume of Waste and Periodic Cover (cy) = 37,651

Volume of Periodic Cover (cy) = (3,765)

Net (Waste) Capacity (cy) = 33,886

Net (Waste) Capacity (tons) = 23,720

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2008.33	2012.64	23,720	23,720	0	5/1/08 Forward Based on 5.5K Tons/Yr

Landfill Life Expectancy (years) = 4.3 August 2012

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 4 / 9
JOB #: HALIFAX-08-1
DATE: 8/27/09
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Capacity Evaluation - Area 2 - Phase 1

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,200	(Assumed)
Waste Density (tcy) =	0.60	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) = 73,129 (Subgrade to Top of Final Cover) **(= Gross Capacity)**

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	0
3 feet	Final Cover =	0 cy
	Sum =	0 cy

Volume of Waste and Periodic Cover (cy) = 73,129

Volume of Periodic Cover (cy) = (7,313)

Net (Waste) Capacity (cy) = 65,816

Net (Waste) Capacity (tons) = 39,490

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2012.78	2018.05	39,490	39,490	(0)	**Based on 7,500 TPY**

Landfill Life Expectancy (years) = 5.3

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 519
JOB #: HALIFAX-08-1
DATE: 8/27/09
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Capacity Evaluation - Area 2 - Phase 2

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,200	(Assumed)
Waste Density (tcy) =	0.60	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) = 90,571 (Subgrade to Top of Final Cover) **(= Gross Capacity)**

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	1.5
3 feet	Final Cover =	(7,260) cy
	Sum =	(7,260) cy
	Volume of Waste and Periodic Cover (cy) =	83,311
	Volume of Periodic Cover (cy) =	(8,331)
	Net (Waste) Capacity (cy) =	74,980
	Net (Waste) Capacity (tons) =	44,988

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2018.05	2024.05	44,988	44,988	(0)	**Based on 7,500 TPY**

Landfill Life Expectancy (years) = 6.0

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Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
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SHEET: 6 / 9
JOB #: HALIFAX-08-1
DATE: 8/27/09
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Capacity Evaluation - Area 2 - Phase 3

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,200	(Assumed)
Waste Density (tcy) =	0.60	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) = 102,568 (Subgrade to Top of Final Cover) **(= Gross Capacity)**

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	4.2
3 feet	Final Cover =	(20,328) cy
	Sum =	(20,328) cy
	Volume of Waste and Periodic Cover (cy) =	82,240
	Volume of Periodic Cover (cy) =	(8,224)
	Net (Waste) Capacity (cy) =	74,016
	Net (Waste) Capacity (tons) =	44,410

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2024.05	2029.97	44,410	44,410	(0)	**Based on 7,500 TPY**

Landfill Life Expectancy (years) = 5.9

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Engineering and Geological Services
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Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 7 /9
JOB #: HALIFAX-08-1
DATE: 8/27/09
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Capacity Evaluation - Summary

Landfill Unit	Area (Acres)	Gross Capacity (CY)	Net (Waste) Capacity (See Note 1)		Life Expectancy (Years) (See Note 2)
			(CY)	(Tons)	
C&D Landfill Units					
Area 1 (Filled)	6.2	67,399	60,659	51,616	-----
Area 1 (Remaining)	-----	63,868	34,975	24,483	4.5
Area 2 - Phase 1	3.3	73,129	65,816	39,490	5.3
Area 2 - Phase 2	2.4	90,571	74,980	44,988	6.0
Area 2 - Phase 3	-----	102,568	74,016	44,410	5.9
Total (C&D)	11.9	397,535	310,446	204,987	21.7

Notes:
1. Net capacity is based on an assumed 10% periodic cover soil ratio and waste density of 0.7 tons/cy (Area 1) and 0.6 tons/cy (Area 2).
2. Area 1 life expectancy is based on an assumed average disposal rate of 5,500 tons/year and is projected from May 1, 2008.
3. Area 2 life expectancy is based on an assumed average disposal rate of 7,500 tons/year.

266,268 214,812 128,888 17.2

Halifax County Solid Waste Dept.
Volume Report 5/1/2008
9/2/2008

version	date	time	surfBase	surfCompare	volCut	volFill	volNet
1	9/2/2008	15-57-38	TOPO 0902	SURVEY_050108	8,058.73	40,879.14	32,820.41
1	9/2/2008	15-57-38	SURVEY_050108	AREA_1 FCVR	917.54	64,785.69	63,868.15 ←

3/9

Index	Surface Pair		Volume			
	Base Surface	Comparison Surface	Cut	Fill	Net	Net Graph
~~1~~	~~TOPO-0902-SURVEY~~	~~CD-FCVR-032106~~	~~358.94 Cu. Yd.~~	~~101118.50 Cu. Yd.~~	~~100759.56 Cu. Yd. <Fill>~~	
~~2~~	~~TOPO-0901~~	~~SGRD-022206~~	~~81145.11 Cu. Yd.~~	~~8641.33 Cu. Yd.~~	~~72598.77 Cu. Yd. <Cut>~~	
3	SGRD-022206	PHASE1-040306	14.17 Cu. Yd.	73143.12 Cu. Yd.	73128.95 Cu. Yd. <Fill> ← PH1	
4	SGRD-022206	PHASE2	0.19 Cu. Yd.	163771.73 Cu. Yd.	163771.54 Cu. Yd. <Fill>	
5	PHASE1-040306	PHASE2	0.87 Cu. Yd.	90572.08 Cu. Yd.	90571.21 Cu. Yd. <Fill> ← PH.2	
6	SGRD-022206	FCVR-022206	0.00 Cu. Yd.	266291.17 Cu. Yd.	266291.17 Cu. Yd. <Fill>	
7	PHASE2	FCVR-022206	0.14 Cu. Yd.	102567.65 Cu. Yd.	102567.51 Cu. Yd. <Fill> ← PH.3	

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PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Earthwork Quantities

SHEET 1 OF
JOB NO. HALIFAX-08-1
DATE 1/29/10
COMPUTED BY PKS
CHECKED BY

Objective To determine the earthwork and related material quantities associated with the construction and operation of the landfill.

Analysis The volumes of each material will be calculated by taking design thicknesses and/or cross sections and multiplying by design areas and/or lengths. Areas and lengths are determined using AutoCAD, a planimeter, and/or direct measurement.

EARTHWORK.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 2/4
JOB #: HALIFAX-08-1
DATE: 1/29/10
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Earthwork Quantities

Area 1 (From 5/1/08):

Periodic Cover Soil Volume:

Volume of Periodic Cover (cy) = 3,765 **(User Input - From Density & Life Calcs.)**

Final Cover Soil Volume:

Volume of Final Cover Soil (cy) = 26,217 **(User Input - From Density & Life Calcs.)**

Area 2 - Phase 1:

Subgrade Cut and Fill Volumes:

Volume of Cut (cy) = 81,145 **(User Input - From AutoCAD - See Attached)**
Volume of Fill (cy) = 8,644 **(User Input - From AutoCAD - See Attached)**

Periodic Cover Soil Volume:

Volume of Periodic Cover (cy) = 7,313 **(User Input - From Density & Life Calcs.)**

Final Cover Soil Volume:

Volume of Final Cover Soil (cy) = 0 **(User Input - From Density & Life Calcs.)**

Area 2 - Phase 2:

Periodic Cover Soil Volume:

Volume of Periodic Cover (cy) = 8,331 **(User Input - From Density & Life Calcs.)**

Final Cover Soil Volume:

Volume of Final Cover Soil (cy) = 7,260 **(User Input - From Density & Life Calcs.)**

Area 2 - Phase 3:

Periodic Cover Soil Volume:

Volume of Periodic Cover (cy) = 8,224 **(User Input - From Density & Life Calcs.)**

Final Cover Soil Volume:

Volume of Final Cover Soil (cy) = 20,328 **(User Input - From Density & Life Calcs.)**

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Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 3 / 4
JOB #: HALIFAX-08-1
DATE: 1/29/10
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Earthwork Quantities - Summary

Landfill Unit	General Earthwork		Periodic Cover (CY)	Final Cover Soil (CY)
	Cut (CY)	Fill (CY)		
Area 1			3,765	26,217
Area 2 - Phase 1	81,145	8,644	7,313	
Area 2 - Phase 2			8,331	7,260
Area 2 - Phase 3			8,224	20,328
Totals (CY) =	**81,145**	**8,644**	**27,633**	**53,805**
			On-Site Soil Balance (CY) =	(8,937)

Index	Surface Pair		Volume			
	Base Surface	Comparison Surface	Cut	Fill	Net	Net Graph
1	TOPO-0902-SURVEY	CD-FCVR-032106	358.94 Cu. Yd.	101118.50 Cu. Yd.	100759.56 Cu. Yd. <Fill>	
2	TOPO-0901	SGRD-022206	81145.11 Cu. Yd.	8644.33 Cu. Yd.	72500.77 Cu. Yd. <Cut> ← Area 2 Cut & Fill	
3	SGRD-022206	PHASE1-040306	14.17 Cu. Yd.	73143.12 Cu. Yd.	73128.95 Cu. Yd. <Fill>	
4	SGRD-022206	PHASE2	0.19 Cu. Yd.	163771.73 Cu. Yd.	163771.54 Cu. Yd. <Fill>	
5	PHASE1-040306	PHASE2	0.87 Cu. Yd.	90572.08 Cu. Yd.	90571.21 Cu. Yd. <Fill>	
6	SGRD-022206	FCVR-022206	0.00 Cu. Yd.	266291.17 Cu. Yd.	266291.17 Cu. Yd. <Fill>	
7	PHASE2	FCVR-022206	0.14 Cu. Yd.	102567.65 Cu. Yd.	102567.51 Cu. Yd. <Fill>	

PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Slope Stability Evaluation

SHEET 1 OF 7
JOB NO. HALIFAX-08-1
DATE 4/30/08
COMPUTED BY PKS
CHECKED BY

Objective

To perform a slope stability evaluation for the C&D landfill. Note that only static conditions were evaluated in that the landfill is not in a seismic impact zone (a_{peak} = 0.09). Based on EPA guidance for MSW landfills (EPA/600/R-95/051), landfills are required to have a minimum long-term static factor of safety of 1.5.

Analysis

The slope stability evaluations for the overall C&D landfill area were performed using the computer program STABL5M, a computer program developed by Purdue University.

The slope stability evaluation was performed on the worst case cross section shown on the attached figure (final grades shown). The shear strength envelope assumed for the waste in this evaluation was cohesion = 500 psf and phi = 25 degrees; which is believed to be conservative for C&D wastes. Also, the shear strength envelope assumed for the subgrade in this evaluation was cohesion = 100 psf and phi = 25 degrees; which is conservative as well. The result is as follows:

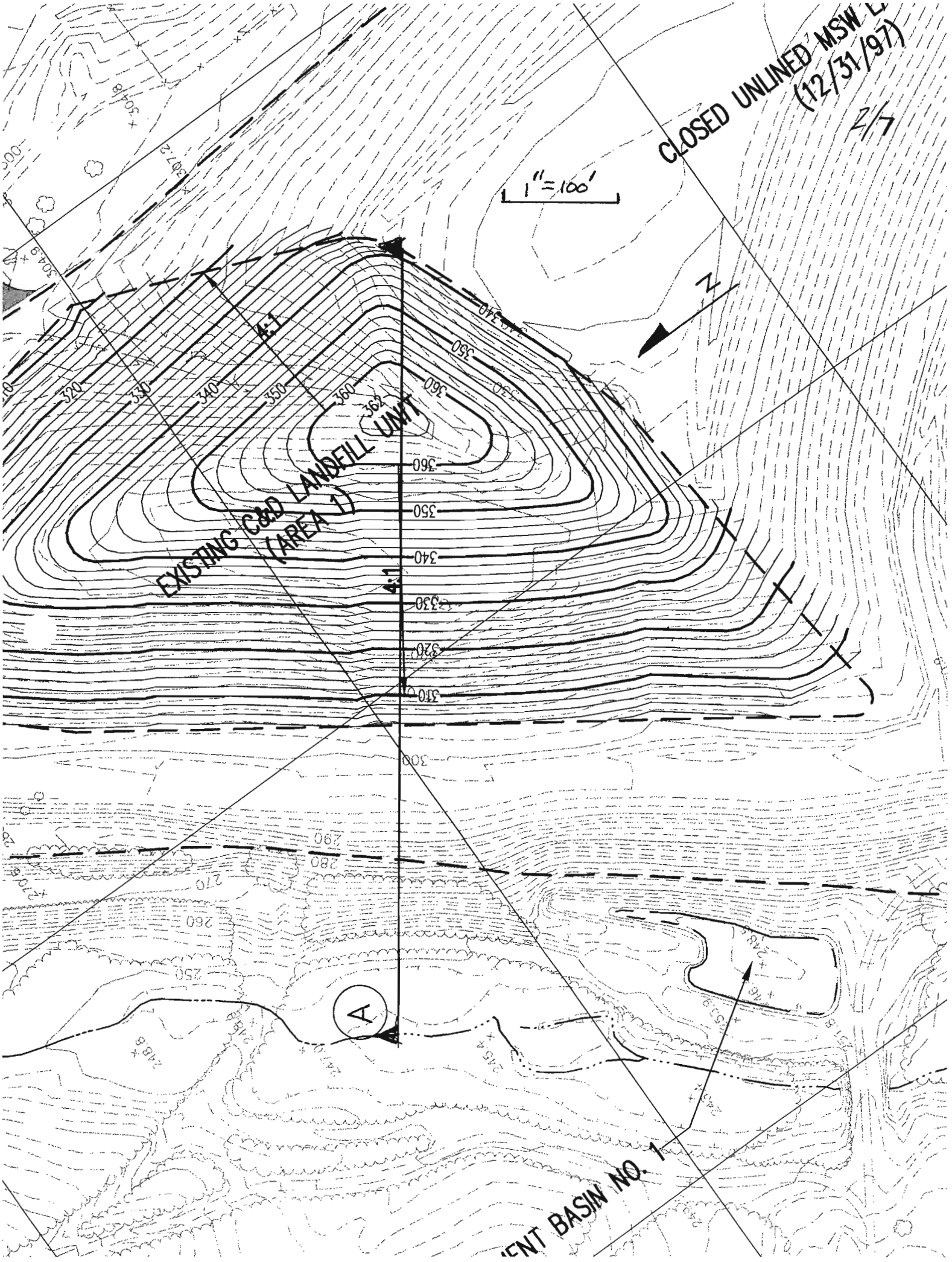
Circular Failure (Static): FS = 1.75

Results

Based on the results of the evaluation (see **attached**), the minimum factor of safety satisfies EPA guidelines.

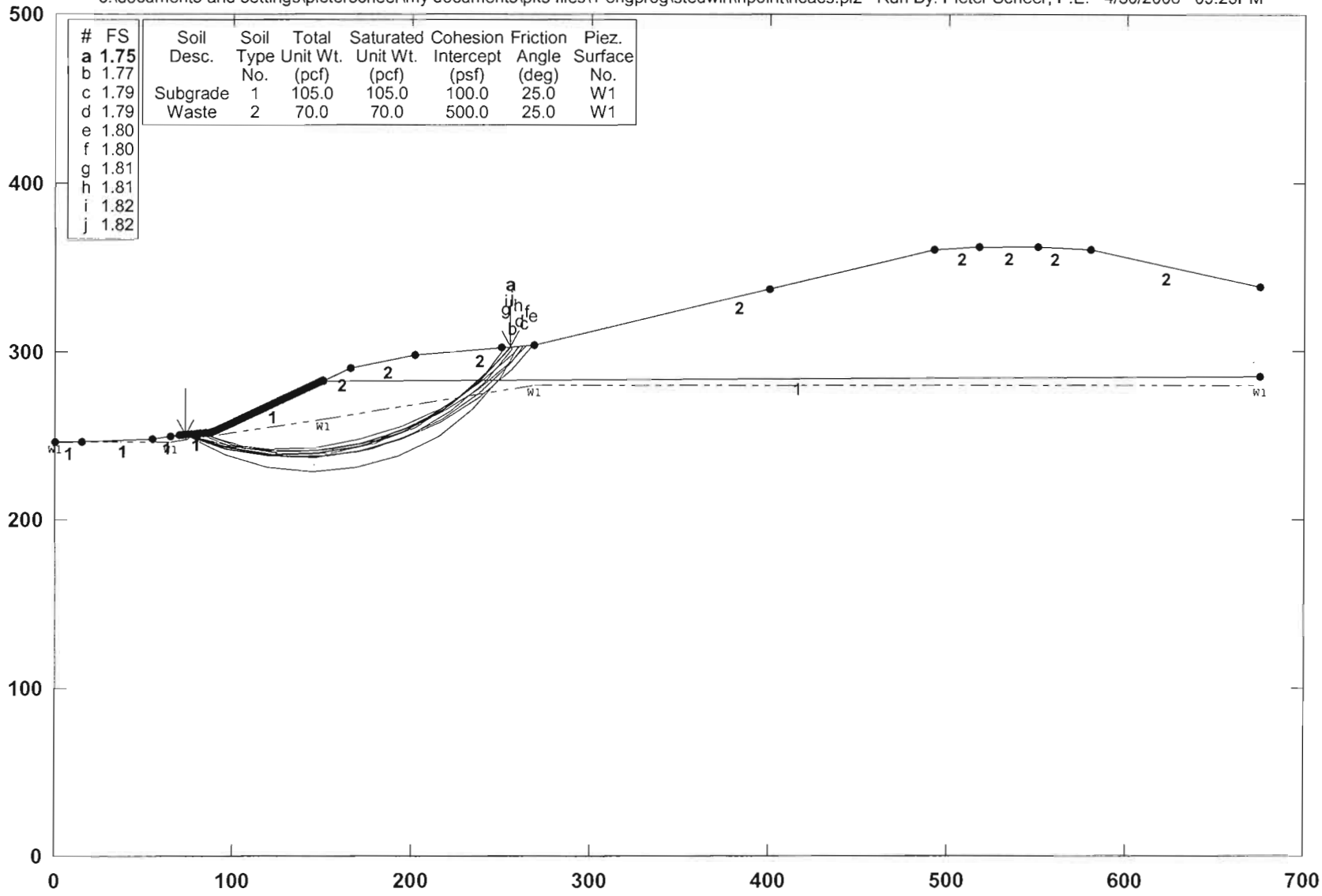
STABILITY.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577


CLOSED UNLINED MSW L
(12/31/97)
2/7
1"=100'
N
4:1
4:1
EXISTING CLOSED LANDFILL UNIT
(AREA 1)
320
330
340
350
360
364
A
ENT BASIN NO.

Halifax County C&DLF - Area 1 - Sect. A Circular - Static

c:\documents and settings\pieterscheer\my documents\pks files\1 engprog\stedwin\hpoint\hcacs.pl2 Run By: Pieter Scheer, P.E. 4/30/2008 09:25PM



PCSTABL5M/si FSmin=1.75

Safety Factors Are Calculated By The Modified Bishop Method

3/7

** PCSTABL5M **
by
Purdue University
--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 4/30/2008
Time of Run: 09:25PM
Run By: Pieter Scheer, P.E.
Input Data Filename: C:HCACS.in
Output Filename: C:HCACS.OUT
Unit: ENGLISH
Plotted Output Filename: C:HCACS.PLT
PROBLEM DESCRIPTION Halifax County C&DLF - Area 1 - Sect. A
Circular - Static

BOUNDARY COORDINATES
13 Top Boundaries
14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	246.00	15.00	246.00	1
2	15.00	246.00	55.00	248.00	1
3	55.00	248.00	65.00	250.00	1
4	65.00	250.00	88.00	252.00	1
5	88.00	252.00	150.00	283.00	1
6	150.00	283.00	165.00	290.00	2
7	165.00	290.00	202.00	298.00	2
8	202.00	298.00	268.00	304.00	2
9	268.00	304.00	492.00	360.00	2
10	492.00	360.00	517.00	362.00	2
11	517.00	362.00	550.00	362.00	2
12	550.00	362.00	580.00	360.00	2
13	580.00	360.00	675.00	338.00	2
14	150.00	283.00	675.00	285.00	1

ISOTROPIC SOIL PARAMETERS
2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	105.0	100.0	25.0	.00	.0	1
2	70.0	70.0	500.0	25.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED
Unit Weight of Water = 62.40
Piezometric Surface No. 1 Specified by 5 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	246.00
2	65.00	246.00
3	150.00	260.00
4	268.00	280.00
5	675.00	280.00

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
2500 Trial Surfaces Have Been Generated.
50 Surfaces Initiate From Each Of 50 Points Equally Spaced
Along The Ground Surface Between X = 70.00 ft.
and X = 150.00 ft.
Each Surface Terminates Between X = 250.00 ft.
and X = 400.00 ft.
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y =150.00 ft.
25.00 ft. Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.27	250.72
2	97.03	242.94
3	121.74	239.20
4	146.74	239.60
5	171.33	244.12
6	194.83	252.65
7	216.60	264.94
8	236.04	280.66
9	252.61	299.38
10	254.74	302.79

Circle Center At X = 131.8 ; Y = 388.9 and Radius, 150.1

*** 1.748 ***

Individual data on the 16 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	6.8	1012.8	.0	.0	.0	.0	.0	.0	.0
2	7.9	3708.0	.0	997.0	.0	.0	.0	.0	.0
3	9.0	9322.0	.0	3573.7	.0	.0	.0	.0	.0
4	24.7	56112.3	.0	18838.2	.0	.0	.0	.0	.0
5	25.0	93754.4	.0	27714.9	.0	.0	.0	.0	.0
6	3.3	14468.5	.0	4046.2	.0	.0	.0	.0	.0
7	15.0	68929.0	.0	18480.1	.0	.0	.0	.0	.0
8	6.3	29641.7	.0	7736.1	.0	.0	.0	.0	.0
9	23.5	103469.1	.0	26491.1	.0	.0	.0	.0	.0
10	7.2	28511.2	.0	6856.6	.0	.0	.0	.0	.0
11	14.6	50127.4	.0	9524.9	.0	.0	.0	.0	.0
12	9.9	26400.0	.0	2494.2	.0	.0	.0	.0	.0
13	9.5	18032.1	.0	.0	.0	.0	.0	.0	.0
14	2.4	3294.2	.0	.0	.0	.0	.0	.0	.0
15	14.2	10535.6	.0	.0	.0	.0	.0	.0	.0
16	2.1	240.6	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	74.90	250.86
2	98.81	243.57
3	123.59	240.25
4	148.58	241.00
5	173.12	245.79
6	196.55	254.49
7	218.27	266.88
8	237.69	282.62
9	254.30	301.31
10	255.27	302.84

Circle Center At X = 131.5 ; Y = 393.4 and Radius, 153.4

*** 1.767 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.27	250.72
2	96.80	242.28
3	121.39	237.78
4	146.39	237.33
5	171.12	240.95
6	194.94	248.54
7	217.21	259.90
8	237.34	274.72
9	254.80	292.62
10	262.39	303.49

Circle Center At X = 136.5 ; Y = 389.3 and Radius, 152.3

*** 1.788 ***

Failure Surface Specified By 10 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	71.63	250.58
2	95.94	244.71
3	120.82	242.29
4	145.80	243.35
5	170.38	247.88
6	194.10	255.78
7	216.49	266.90
8	237.11	281.04
9	255.57	297.90
10	260.01	303.27

Circle Center At X = 125.7 ; Y = 420.4 and Radius, 178.2

*** 1.793 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	71.63	250.58
2	95.30	242.51
3	119.91	238.14
4	144.91	237.58
5	169.69	240.84
6	193.69	247.85
7	216.34	258.43
8	237.11	272.34
9	255.52	289.26
10	267.25	303.93

Circle Center At X = 136.0 ; Y = 400.0 and Radius, 162.7

*** 1.800 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	71.63	250.58
2	95.78	244.09
3	120.59	241.07
4	145.59	241.60
5	170.26	245.66
6	194.10	253.16
7	216.65	263.96
8	237.45	277.83
9	256.07	294.51
10	263.71	303.61

Circle Center At X = 129.3 ; Y = 416.0 and Radius, 175.2

*** 1.801 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	81.43	251.43
2	104.96	243.00
3	129.66	239.08
4	154.64	239.81
5	179.07	245.16
6	202.07	254.95
7	222.86	268.84
8	240.71	286.34
9	252.00	302.55

Circle Center At X = 138.3 ; Y = 373.0 and Radius, 134.2

*** 1.813 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.27	250.72
2	95.17	238.68
3	119.03	231.20
4	143.89	228.57
5	168.78	230.90
6	192.72	238.11
7	214.77	249.89

8	234.06	265.80
9	249.83	285.20
10	259.29	303.21

Circle Center At X = 144.5 ; Y = 354.1 and Radius, 125.5

*** 1.814 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	81.43	251.43
2	105.28	243.94
3	130.08	240.75
4	155.05	241.95
5	179.42	247.50
6	202.45	257.24
7	223.42	270.85
8	241.68	287.93
9	252.67	302.61

Circle Center At X = 135.8 ; Y = 382.9 and Radius, 142.2

*** 1.815 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	79.80	251.29
2	103.13	242.31
3	127.71	237.77
4	152.71	237.82
5	177.28	242.46
6	200.58	251.54
7	221.81	264.73
8	240.26	281.60
9	255.30	301.57
10	255.96	302.91

Circle Center At X = 139.9 ; Y = 372.5 and Radius, 135.3

*** 1.818 ***

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PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Final Cover Infiltration Analysis

SHEET 1 OF 12
JOB NO. HALIFAX-08-1
DATE 1/6/10
COMPUTED BY PKS
CHECKED BY

Objective

To determine the expected average annual infiltration into the landfill through the proposed final cover system. In that the proposed final cover system is an alternate system to the regulatory final cover, the infiltration through the proposed system is compared to the infiltration through the regulatory system. Use the EPA HELP Model (v. 3.07) in the analysis.

References

Schroeder, P.R., Lloyd, C.M., et. al, (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model - User's Guide for Version 3," EPA/600/9-94/168a, USEPA Risk Reduction Laboratory, Cincinnati, Ohio.

Schroeder, P.R., Lloyd, C.M., et. al, (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model - Engineering Documentation for Version 3," EPA/600/9-94/168b, USEPA Risk Reduction Laboratory, Cincinnati, Ohio.

Analysis

Final Cover Systems Analyzed:

1A. Proposed Final Cover System (Top Slopes - 5 to 10%): (Top Down)

A. 18 inches Vegetative Soil Layer
B. Drainage Geocomposite
C. 30 mil Textured LLDPE Geomembrane or Geosynthetic Clay Liner (GCL)
D. 12 inches Intermediate Cover

1B. Proposed Final Cover System (Side Slopes - 4H:1V):

A. 24 inches Vegetative Soil Layer

2. Regulatory Final Cover System: (Top Down)

A. 18 inches Vegetative Soil Layer
B. 18 inches Compacted Soil Barrier ($k = 2.8 \times 10^{-7}$ cm/sec = Avg. of Underlying Cover System)
C. 12 inches Intermediate Cover

Results

The results as summarized below show that the proposed final cover system allows less infiltration than the regulatory final cover system. HELP Model runs are attached.

Case	Avg. Annual Infiltration (in)
1A (GM)	0.03
1A (GCL)	0.04
1B (Soil)	10.11
2 (RMC)	10.07

FCS HELP.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

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**                                                                  **
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**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE            **
**            HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)            **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY               **
**                USAE WATERWAYS EXPERIMENT STATION                 **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY          **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:      C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:  C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:    C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:  C:\PROGRA~1\HELP3\HCGM08.D10
OUTPUT DATA FILE:           C:\PROGRA~1\HELP3\HCGM08.OUT

TIME:  13:56     DATE:  1/ 6/2010

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     TITLE:  Halifax County C&DLF - Case 1A (GM) (8% Slope)

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


                                LAYER  1
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   6
        THICKNESS                     =     18.00   INCHES
        POROSITY                      =      0.4530 VOL/VOL
        FIELD CAPACITY                =      0.1900 VOL/VOL
        WILTING POINT                 =      0.0850 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.2060 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.720000011000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
             FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
                                --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER  20
        THICKNESS                     =      0.25   INCHES
        POROSITY                      =      0.8500 VOL/VOL
        FIELD CAPACITY                =      0.0100 VOL/VOL
        WILTING POINT                 =      0.0050 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.1764 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  10.0000000000      CM/SEC
        SLOPE                         =      8.00   PERCENT
        DRAINAGE LENGTH               =    100.0    FEET


                                LAYER  3
                                --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  36
        THICKNESS                     =      0.03   INCHES
        POROSITY                      =      0.0000 VOL/VOL
        FIELD CAPACITY                =      0.0000 VOL/VOL
        WILTING POINT                 =      0.0000 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.0000 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.399999993000E-12 CM/SEC
        FML PINHOLE DENSITY           =      1.00   HOLES/ACRE
        FML INSTALLATION DEFECTS      =      8.00   HOLES/ACRE
        FML PLACEMENT QUALITY         =  3 - GOOD


                                LAYER  4
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   6
        THICKNESS                     =     12.00   INCHES
        POROSITY                      =      0.4530 VOL/VOL
        FIELD CAPACITY                =      0.1900 VOL/VOL
        WILTING POINT                 =      0.0850 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.1741 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.720000011000E-03 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ---------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
            FAIR STAND OF GRASS, A SURFACE SLOPE OF  8.%
            AND A SLOPE LENGTH OF  100. FEET.

    SCS RUNOFF CURVE NUMBER           =     72.30
    FRACTION OF AREA ALLOWING RUNOFF  =    100.0    PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =     1.000  ACRES
    EVAPORATIVE ZONE DEPTH            =     18.2    INCHES
    INITIAL WATER IN EVAPORATIVE ZONE  =     3.753  INCHES
```

UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.367	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.531	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	5.843	INCHES
TOTAL INITIAL WATER	=	5.843	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	86
END OF GROWING SEASON (JULIAN DATE)	=	310
EVAPORATIVE ZONE DEPTH	=	18.2 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.016	0.000	0.007	0.001	0.027	0.003
	0.004	0.083	0.009	0.004	0.008	0.003
STD. DEVIATIONS	0.038	0.001	0.025	0.004	0.085	0.012
	0.017	0.270	0.039	0.017	0.028	0.011
EVAPOTRANSPIRATION						
TOTALS	1.520	1.800	2.970	2.638	3.811	3.581
	3.915	4.136	2.435	1.355	1.312	1.140
STD. DEVIATIONS	0.135	0.248	0.380	0.974	1.076	1.679
	1.482	1.252	1.164	0.440	0.159	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.0523	1.3017	1.0819	0.3393	0.6141	0.2491
	0.1727	1.1050	0.2476	0.5827	1.3652	1.3503
STD. DEVIATIONS	1.7600	1.0796	1.0504	0.6265	1.1651	0.4510
	0.4236	2.2472	0.7942	0.9857	1.2188	0.9218
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0034	0.0024	0.0020	0.0007	0.0009	0.0004
	0.0003	0.0015	0.0004	0.0009	0.0025	0.0026
STD. DEVIATIONS	0.0024	0.0017	0.0016	0.0010	0.0016	0.0008
	0.0007	0.0027	0.0010	0.0014	0.0019	0.0015
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0057	0.0036	0.0048	0.0024	0.0008	0.0006
	0.0007	0.0009	0.0006	0.0019	0.0038	0.0048
STD. DEVIATIONS	0.0053	0.0021	0.0052	0.0024	0.0012	0.0013
	0.0015	0.0019	0.0012	0.0037	0.0039	0.0029

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0179	0.0124	0.0094	0.0031	0.0053	0.0022
	0.0015	0.0096	0.0022	0.0051	0.0123	0.0118
STD. DEVIATIONS	0.0153	0.0102	0.0091	0.0056	0.0101	0.0041
	0.0037	0.0196	0.0071	0.0086	0.0110	0.0080

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.166	(0.3304)	601.95	0.402
EVAPOTRANSPIRATION	30.612	(3.4775)	111123.05	74.213
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.46182	(5.79871)	37976.410	25.36230
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.01804	(0.00814)	65.491	0.04374
AVERAGE HEAD ON TOP OF LAYER 3	0.008	(0.004)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.03082	(0.02458)	111.886	0.07472
CHANGE IN WATER STORAGE	-0.021	(0.8859)	-77.60	-0.052

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.110	4030.9146
DRAINAGE COLLECTED FROM LAYER 2	1.59793	5800.49805
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.001452	5.27097
AVERAGE HEAD ON TOP OF LAYER 3	0.431	
MAXIMUM HEAD ON TOP OF LAYER 3	0.833	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	2.7 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001049	3.80829
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3374

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1339

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

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

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	3.5370	0.1965
2	0.0439	0.1756
3	0.0000	0.0000
4	1.8341	0.1528
SNOW WATER	0.000	

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**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE            **
**            HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)            **
**               DEVELOPED BY ENVIRONMENTAL LABORATORY              **
**                 USAE WATERWAYS EXPERIMENT STATION                **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY          **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\HCGCL08.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\HCGCL08.OUT

TIME:  14: 6     DATE:   1/ 6/2010

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

     TITLE:  Halifax County C&DLF - Case 1A (GCL) (8% Slope)

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

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

                                LAYER  1
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   6
     THICKNESS                    =     18.00   INCHES
     POROSITY                     =      0.4530 VOL/VOL
     FIELD CAPACITY               =      0.1900 VOL/VOL
     WILTING POINT                =      0.0850 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.2060 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.720000011000E-03 CM/SEC
   NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
            FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                                LAYER  2
                                --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER  20
     THICKNESS                    =      0.25   INCHES
     POROSITY                     =      0.8500 VOL/VOL
     FIELD CAPACITY               =      0.0100 VOL/VOL
     WILTING POINT                =      0.0050 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.1764 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  10.0000000000      CM/SEC
     SLOPE                        =      8.00   PERCENT
     DRAINAGE LENGTH              =    100.0    FEET

                                LAYER  3
                                --------

                TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =      0.20   INCHES
     POROSITY                     =      0.7500 VOL/VOL
     FIELD CAPACITY               =      0.7470 VOL/VOL
     WILTING POINT                =      0.4000 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

                                LAYER  4
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   6
     THICKNESS                    =     12.00   INCHES
     POROSITY                     =      0.4530 VOL/VOL
     FIELD CAPACITY               =      0.1900 VOL/VOL
     WILTING POINT                =      0.0850 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.1751 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.720000011000E-03 CM/SEC

          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ---------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  8.%
          AND A SLOPE LENGTH OF  100. FEET.

SCS RUNOFF CURVE NUMBER             =     72.30
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     18.2    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      3.753  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.36   INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.531  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
```

21/5

INITIAL WATER IN LAYER MATERIALS	=	6.004	INCHES
TOTAL INITIAL WATER	=	6.004	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	86
END OF GROWING SEASON (JULIAN DATE)	=	310
EVAPORATIVE ZONE DEPTH	=	18.2 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.016	0.000	0.007	0.001	0.027	0.003
	0.004	0.083	0.009	0.004	0.008	0.003
STD. DEVIATIONS	0.037	0.001	0.025	0.004	0.085	0.012
	0.017	0.270	0.039	0.017	0.028	0.011
EVAPOTRANSPIRATION						
TOTALS	1.509	1.799	2.961	2.647	3.804	3.584
	3.921	4.135	2.432	1.357	1.309	1.132
STD. DEVIATIONS	0.146	0.262	0.375	0.975	1.065	1.676
	1.480	1.254	1.165	0.443	0.165	0.119
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.0572	1.3051	1.0900	0.3419	0.6024	0.2493
	0.1691	1.1056	0.2471	0.5855	1.3753	1.3476
STD. DEVIATIONS	1.7613	1.0833	1.0482	0.6292	1.1691	0.4489
	0.4185	2.2492	0.7945	0.9856	1.2079	0.8802
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0049	0.0036	0.0036	0.0016	0.0010	0.0006
	0.0005	0.0011	0.0006	0.0015	0.0037	0.0045
STD. DEVIATIONS	0.0015	0.0016	0.0017	0.0016	0.0013	0.0010
	0.0009	0.0017	0.0010	0.0017	0.0020	0.0014
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0068	0.0046	0.0055	0.0026	0.0012	0.0009
	0.0008	0.0013	0.0008	0.0023	0.0047	0.0056
STD. DEVIATIONS	0.0048	0.0021	0.0051	0.0025	0.0016	0.0017
	0.0015	0.0022	0.0013	0.0038	0.0035	0.0027

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0179	0.0124	0.0095	0.0031	0.0052	0.0022
	0.0015	0.0096	0.0022	0.0051	0.0124	0.0117
STD. DEVIATIONS	0.0153	0.0103	0.0091	0.0057	0.0102	0.0040
	0.0036	0.0196	0.0071	0.0086	0.0109	0.0077

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.25 (8.104)	149735.7	100.00
RUNOFF	0.166 (0.3306)	602.59	0.402
EVAPOTRANSPIRATION	30.589 (3.4697)	111037.03	74.155
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.47606 (5.84412)	38028.109	25.39682
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.02713 (0.00725)	98.475	0.06577
AVERAGE HEAD ON TOP OF LAYER 3	0.008 (0.004)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.03707 (0.02299)	134.577	0.08988
CHANGE IN WATER STORAGE	-0.018 (0.8892)	-66.61	-0.044

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.110	4030.8865
DRAINAGE COLLECTED FROM LAYER 2	1.59857	5802.80469
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000537	1.94988
AVERAGE HEAD ON TOP OF LAYER 3	0.431	
MAXIMUM HEAD ON TOP OF LAYER 3	0.833	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	2.7 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001078	3.91182
SNOW WATER	1.80	6547.7266
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3374	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0839	

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

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

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	3.5408	0.1967
2	0.0439	0.1756
3	0.1500	0.7500
4	1.9023	0.1585
SNOW WATER	0.000	

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**                                                                  **
**                                                                  **
**            HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE          **
**              HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)          **
**               DEVELOPED BY ENVIRONMENTAL LABORATORY              **
**                 USAE WATERWAYS EXPERIMENT STATION                **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY         **
**                                                                  **
**                                                                  **
**********************************************************************
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\HCSOIL25.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\HCSOIL25.OUT

TIME:  13:28     DATE:   1/ 6/2010

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

     TITLE:  Halifax County C&DLF - Cases 1B (Soil) (25%)

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


                                LAYER  1
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   6
       THICKNESS                    =     24.00   INCHES
       POROSITY                     =      0.4530 VOL/VOL
       FIELD CAPACITY               =      0.1900 VOL/VOL
       WILTING POINT                =      0.0850 VOL/VOL
       INITIAL SOIL WATER CONTENT   =      0.2235 VOL/VOL
       EFFECTIVE SAT. HYD. COND.    =  0.72000011000E-03 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
            FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                    GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                    ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
            FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
            AND A SLOPE LENGTH OF  150. FEET.

SCS RUNOFF CURVE NUMBER             =     72.60
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.851  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      9.966  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.870  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      5.365  INCHES
TOTAL INITIAL WATER                 =      5.365  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
            RALEIGH                NORTH CAROLINA

        STATION LATITUDE                      =  35.87 DEGREES
        MAXIMUM LEAF AREA INDEX               =   2.00
        START OF GROWING SEASON (JULIAN DATE) =     86
        END OF GROWING SEASON (JULIAN DATE)   =    310
        EVAPORATIVE ZONE DEPTH                =  22.0  INCHES
        AVERAGE ANNUAL WIND SPEED             =   7.70 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY =  66.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY =  70.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY =  78.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY =  72.00 %

     NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    RALEIGH                NORTH CAROLINA

            NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    3.55        3.43        3.69        2.91        3.67        3.66
    4.38        4.44        3.29        2.73        2.87        3.14
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NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.016	0.000	0.007	0.000	0.023	0.003
	0.004	0.080	0.007	0.003	0.008	0.003
STD. DEVIATIONS	0.038	0.002	0.025	0.000	0.070	0.012
	0.018	0.270	0.032	0.014	0.026	0.011
EVAPOTRANSPIRATION						
TOTALS	1.480	1.783	2.956	2.661	3.993	3.799
	3.976	4.158	2.521	1.341	1.248	1.090
STD. DEVIATIONS	0.136	0.256	0.358	0.953	0.945	1.709
	1.467	1.281	1.170	0.417	0.156	0.146
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	2.1089	1.2844	1.2499	0.5122	0.5725	0.2249
	0.1252	0.8743	0.3413	0.3382	1.1136	1.3600
STD. DEVIATIONS	1.6246	1.0483	0.9898	0.6101	1.0680	0.3682
	0.2880	2.1111	0.9007	0.7594	1.2047	0.9237

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.154	(0.3188)	558.00	0.373
EVAPOTRANSPIRATION	31.007	(3.5665)	112553.82	75.168
PERCOLATION/LEAKAGE THROUGH LAYER 1	10.10523	(5.71996)	36682.000	24.49783
CHANGE IN WATER STORAGE	-0.016	(0.8925)	-58.12	-0.039

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.141	4141.0020
PERCOLATION/LEAKAGE THROUGH LAYER 1	2.472255	8974.28418
SNOW WATER	1.80	6547.7266
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3661	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0850	

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	5.0448	0.2102
SNOW WATER	0.000	

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**                                                                  **
**                                                                  **
**             HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE         **
**               HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)         **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:      C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:  C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:    C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:  C:\PROGRA~1\HELP3\HCRMC.D10
OUTPUT DATA FILE:           C:\PROGRA~1\HELP3\HCRMC.OUT

TIME:  13:27     DATE:   1/ 6/2010

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     TITLE:  Halifax County C&DLF - Case 2 (RMC)

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

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


                                LAYER  1
                                --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   6
     THICKNESS                     =     18.00   INCHES
     POROSITY                      =      0.4530 VOL/VOL
     FIELD CAPACITY                =      0.1900 VOL/VOL
     WILTING POINT                 =      0.0850 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.2146 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.720000011000E-03 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
                                --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
     THICKNESS                     =     18.00   INCHES
     POROSITY                      =      0.4750 VOL/VOL
     FIELD CAPACITY                =      0.3780 VOL/VOL
     WILTING POINT                 =      0.2650 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.4708 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.279999995000E-06 CM/SEC


                                LAYER  3
                                --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   6
     THICKNESS                     =     12.00   INCHES
     POROSITY                      =      0.4530 VOL/VOL
     FIELD CAPACITY                =      0.1900 VOL/VOL
     WILTING POINT                 =      0.0850 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.2623 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.720000011000E-03 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ---------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
               AND A SLOPE LENGTH OF  200. FEET.

     SCS RUNOFF CURVE NUMBER             =     72.10
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
     EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      5.689  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =     10.054  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.590  INCHES
     INITIAL SNOW WATER                  =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =     15.485  INCHES
     TOTAL INITIAL WATER                 =     15.485  INCHES
     TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
               RALEIGH                NORTH CAROLINA

        STATION LATITUDE                      =  35.87 DEGREES
        MAXIMUM LEAF AREA INDEX               =   2.00
        START OF GROWING SEASON (JULIAN DATE) =     86
        END OF GROWING SEASON (JULIAN DATE)   =    310
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21/01

EVAPORATIVE ZONE DEPTH = 22.0 INCHES
AVERAGE ANNUAL WIND SPEED = 7.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.016	0.000	0.007	0.000	0.023	0.003
	0.004	0.079	0.007	0.003	0.007	0.003
STD. DEVIATIONS	0.038	0.002	0.026	0.000	0.069	0.012
	0.016	0.270	0.033	0.013	0.024	0.011
EVAPOTRANSPIRATION						
TOTALS	1.469	1.774	2.950	2.631	4.042	3.876
	3.985	4.144	2.530	1.338	1.237	1.074
STD. DEVIATIONS	0.152	0.251	0.357	0.968	0.897	1.687
	1.462	1.279	1.158	0.402	0.160	0.148
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	1.9718	1.3289	1.3017	0.6761	0.7124	0.4164
	0.3096	0.8291	0.4408	0.2723	0.7183	1.0935
STD. DEVIATIONS	1.5117	0.9420	0.9730	0.4478	0.8963	0.3559
	0.2216	1.7668	0.9359	0.4567	1.2128	0.8267

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.151	(0.3178)	548.55	0.366
EVAPOTRANSPIRATION	31.051	(3.6032)	112713.75	75.275
PERCOLATION/LEAKAGE THROUGH LAYER 3	10.07081	(5.45494)	36557.035	24.41438
CHANGE IN WATER STORAGE	-0.023	(1.1911)	-83.64	-0.056

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.141	4143.3271
PERCOLATION/LEAKAGE THROUGH LAYER 3	2.887094	10480.14940
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3847

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1177

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	3.6791	0.2044
2	8.4662	0.4703
3	2.8791	0.2399
SNOW WATER	0.000	

Technical Specifications

Halifax County C&D Landfill
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

June 2008
Revised: January 2010

RICHARDSON SMITH GARDNER & ASSOCIATES
ENGINEERING & GEOLOGICAL SERVICES

14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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HALIFAX COUNTY C&D LANDFILL

TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

Section No.	Specification
02222	Excavation
02223	Embankment
02240	Geotextiles
02258	Vegetative Soil Layer
02270	Erosion and Sedimentation Control
02271	Rip Rap
02275	Rolled Erosion Control Products
02712	Drainage Geocomposite ***(New - 1/10)***
02720	Storm Water Systems
02776	Geosynthetic Clay Liner ***(New - 1/10)***
02778	LLDPE Geomembrane ***(New - 1/10)***
02930	Revegetation

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SECTION 02222

EXCAVATION

Excavation: Excavation includes excavating, sealing, hauling, scraping, undercutting, removal of accumulated surface water or ground water, stockpiling, and all necessary and incidental items as required for bringing the landfill and related structures to the specified lines and grades.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment required to complete Excavation of the project area in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Embankment	02223
Erosion and Sedimentation Control	02270
CQA Manual	Attached

3. Quality Assurance:

Quality Assurance during Excavation will be provided by the Owner as described in the accompanying Project CQA Manual.

4. Definitions:

a. Excavation: shall consist of the removal and satisfactory disposal and/or stockpiling of materials located with the limits of construction including widening cuts and shaping of slopes necessary for the preparation of roadbeds, landfill slope areas, cutting of any ditches, channels, waterways, entrances, and other work incidental thereto.

b. Borrow: shall consist of approved on-site material required for the construction of embankments/fills or for other portions of the work.

c. Select Borrow: shall consist of approved off-site material required for the construction of embankments/fills, roadway subgrade, backfilling, or for other portions of the work as shown on Contract Drawings or in these Specifications. The Contractor shall make his own arrangements for obtaining select borrow and pay all costs involved.

d. Unsuitable Material: is any in-place or excavated material which contains undesirable materials, or is in a state which is not appropriate; in the opinion of the CQA Engineer, for the intended use or support of planned structures, embankment, or excavation. This may include but not be limited to organic material, waste/refuse, soft, or wet material not meeting required specifications, etc.

e. Unsuitable Materials Excavation (Overexcavation): shall consist of the removal and satisfactory disposal of all unsuitable material located within the limits of construction. Where excavation to the finished grade section shown results in a subgrade or slopes of unsuitable material, the Contractor shall overexcavate such material to below the grade shown on the Contract Drawings or as directed by the Engineer and CQA Engineer.

B. MATERIALS

Excavation shall include the removal of all soil, weathered rock, boulders, conduits, pipe, and all other obstacles encountered and shown on the Contract Drawings or specified herein.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer before approval is given to proceed:

1. Descriptive information on Excavation equipment to be used.

D. CONSTRUCTION

1. The Contractor shall conduct Excavation activities in such a manner that erosion of disturbed areas and off site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. The Contractor shall excavate to the lines and grades shown on the Contract Drawings and stockpile all suitable excavated materials. As the excavation is made, the materials will be examined and identified to the CQA Engineer.

The Contractor will perform all surveys necessary to establish and verify lines and grades for all Excavation, including pipe excavations, soil overexcavation, and anchor trenches.

3. Stockpiling:

   The Contractor shall stockpile the materials in appropriate stockpiles as approved by the CQA Engineer.

   Stockpiles shall be properly sloped and the surfaces sealed by the Contractor at the end of each working day, or during the day in the event of heavy rain, to the satisfaction of the Engineer.

4. The Contractor shall protect all existing facilities and structures including, but not limited to, existing utilities, monitoring wells, signs, grade stakes, etc. during the grading and stockpiling operations.

5. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such sheeting, timbering, pumping, and drainage as may be required.

6. The Contractor shall be responsible for the control of surface and subsurface water when necessary.

7. Excavation slopes shall be flat enough to avoid sloughs and slides that will cause disturbance of the subgrade or damage of adjacent areas. Slides and overbreaks which occur due to negligence, carelessness, or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as directed by the Engineer at no additional cost to the Owner.

8. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded. All protruding roots and other vegetation shall be removed from slopes.

9. The bottom of all excavations for structures and pipes shall be examined by the CQA Engineer for bearing value and the presence of unsuitable material. If, in the opinion of the CQA Engineer, additional Excavation is required due to the low bearing value of the subgrade material, or if the in-place materials are soft, yielding, pumping and wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted structural fill, or material directed by the CQA Engineer. No payment will be made for subgrade disturbance caused by inadequate Dewatering or improper construction methods.

10. Any areas excavated below design subgrade elevations by the Contractor, unless directed by the CQA Engineer, shall be brought back to design elevations at no cost to the Owner. The Contractor shall place and compact such material in accordance with Section 02223, Embankment, of these Specifications.

11. The Contractor shall dispose of excess or unsuitable excavation materials on-site at location(s) approved by the Owner.

12. The Contractor shall properly level-off bottoms of all excavations. Proof-rolling shall be conducted with appropriate equipment.

13. Upon reaching subgrade elevations shown in excavation areas, the Contractor shall scarify subgrade soils to a minimum depth of 6" and obtain the CQA Engineer's approval of quality. If unsuitable materials are encountered at the subgrade elevation, perform additional excavations as approved by the CQA Engineer to remove unsuitable materials.

14. Overexcavation and Backfill:

    Where subgrade materials are determined to be unsuitable, such materials shall be removed by the Contractor to the lengths, widths and depths approved by the CQA Engineer and backfilled with suitable material in accordance with Section 02223, Embankment, of these Specifications unless further excavation or earthwork is required. No additional payment will be made for such excavation and backfill 1 foot or less than the finished subgrade. Unsuitable material excavation greater than 1 foot beneath the finished subgrade shall be made on a unit price basis for excavation and backfill, only as approved by the Engineer and CQA Engineer prior to the work. Unit price for overexcavation and backfill greater than 1 foot in depth shall include disposal of unsuitable materials.

15. All cuts shall be brought to the grade and cross section shown on the Contract Drawings, or established by the Engineer, prior to final inspection.

16. The Contractor shall protect finished lines and grades of completed excavation against excessive erosion, damage from trafficking, or other causes and shall repair any damage at no additional cost to the Owner.

17. Trench Excavation:

    a. All pipe Excavation and trenching shall be done in strict accordance with these Specifications, all applicable parts of the OSHA Regulations, 29 CFR 1926, Subpart P, and other applicable regulations. In the event of any conflicts in this information, safe working conditions as established by the appropriate OSHA guidelines shall govern.

b. The minimum trench widths shall be as indicated on the Contract Drawings. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Contract Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing.

c. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.

d. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, obstructions, or structures.

e. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet.

f. Pipe Bedding: All pipe bedding shall be as shown on the Contract Drawings, unless otherwise specified herein.

18. Sheeting and Bracing:

a. The Contractor shall furnish, place, and maintain such sheeting and bracing which may be required to support sides of Excavation or to protect pipes and structures from possible damage and to provide safe working conditions in accordance with current OSHA requirements. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the sole expense of the Contractor. The Contractor shall be responsible for the adequacy of all sheeting and bracing used and for all damage resulting from sheeting and bracing failure or from placing, maintaining, and removing it.

b. The Contractor shall exercise caution in the installation and removal of sheeting to insure that excessive or unusual loadings are not transmitted to any new or existing structure. The Contractor shall promptly repair at his expense any and all damage that can be reasonably attributed to sheeting installation or removal.

c. All sheeting and bracing shall be removed upon completion of the work.

19. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed at the Contractor's sole expense.

END OF SECTION

SECTION 02223

EMBANKMENT

Embankment: Embankment is the on-site compacted fill that provides the foundation and the berms for the containment area, the subgrade for some access roadways and structures, and backfill around structures and piping.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Embankment including borrowing, hauling, screening, discing, drying, compaction, control of surface and subsurface water, final grading, sealing, and all necessary and incidental items as detailed or required to complete the Embankment, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

4. Quality Assurance:

Quality Assurance during placement of Embankment will be provided by the Owner as described in the accompanying Project CQA Manual.

5. Definitions:

a Embankment: Shall include construction of all site earthwork including roadways, subgrade, perimeter berm embankments, including preparation of the areas upon which materials are to be placed. Embankment may also be referred to as structural and/or controlled fill. All Embankment materials may be either (off-site) Select Borrow or (on-site) Borrow unless otherwise noted on Contract Drawings or specified by the Engineer.

b. Prepared Subgrade: The ground surface after clearing, grubbing, stripping, excavation, scarification, and/or compaction, and/or proof rolling to the satisfaction of the CQA Engineer.

c. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters. Well-graded is used to define a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

d. Unclassified Fill: The nature of materials to be used is not identified or described herein but must be approved by the Engineer prior to use.

B. MATERIALS

1. Embankment materials shall consist of clean well-graded natural soil classified as SW, SM, SM-SC, SC, ML, CL-ML, or CL (ASTM D 2488) containing no topsoil or other deleterious material. Other material classifications may be approved by the Engineer.

2. Stones or rock fragments shall not exceed one half the maximum lift thickness as compacted in any dimension. Isolated rocks shall be a maximum of 24-inches in any dimension.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer before approval is given to proceed:

1. Descriptive information on compaction equipment to be used for construction of Embankment.

2. Descriptive information on the location and source of any off-site borrow material to be used for Embankment, where applicable. Information shall include Standard Proctor curves (ASTM D698) for each borrow material.

D. CONSTRUCTION

1. The Contractor shall conduct Embankment activities in such a manner that erosion of disturbed areas and off-site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. All placement and compaction of Embankment shall be performed only when the CQA Engineer is informed by the Contractor of intent to perform such work.

3. Embankment shall be placed and compacted to the lines and grades shown on the Contract Drawings. Placement of Embankment outside the construction limits shall occur only as directed and approved by the Engineer.

   The Contractor will perform all surveys necessary to establish and verify lines and grades for all Embankment.

4. The Contractor shall protect all existing facilities including, but not limited to, utilities and monitoring wells.

5. Subgrade Preparation:

   a. The CQA Engineer shall inspect the exposed subgrade prior to placement of Embankment to assure that all rocks, topsoil, vegetation, roots, debris, or other deleterious materials have been removed.

   b. Prior to placement of Embankment, the exposed subgrade shall be proofrolled using a static smooth-drum roller, loaded tandem axle dump truck, or other suitable equipment in the presence of the CQA Engineer. Any soft or unsuitable materials revealed before or during the in-place compaction shall be removed as directed by the CQA Engineer and replaced with suitable Embankment.

6. Surfaces on which Embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the Embankment with the existing surface.

7. The Contractor shall be responsible for preparing the materials for the Embankment, including but not limited to, in-place drying or wetting of the soil necessary to achieve the compaction criteria of these Specifications.

8. The Contractor shall be responsible for the control of surface and subsurface water, when necessary.

9. Embankment materials shall be placed in a manner permitting drainage and in continuous, approximately horizontal layers.

10. Compaction Requirements:

    a. The Contractor shall compact Embankment in accordance with the requirements shown in Table 1 of this section. If Embankment does not meet the specified requirements, the Contractor shall rework the material, as may be necessary and continue compaction to achieve these requirements, or remove and replace the material to achieve the specified requirements, at Contractor's expense.

    b. Each lift shall be compacted prior to placement of succeeding lifts. In confined areas, mechanical equipment, suitable for small areas and capable of achieving the density requirements, shall be required.

    c. Lift compaction shall be performed with an appropriately heavy, properly ballasted, penetrating-foot or smooth-drum vibratory compactor depending on soil type. Compaction equipment shall be subject to approval by the CQA Engineer.

11. Embankment that becomes excessively eroded, soft, or otherwise unsuitable shall be removed or repaired by the Contractor as directed by the CQA Engineer, at no cost to the Owner.

12. The exposed surface of Embankment shall be rolled with a smooth-drum roller at the end of each work day to protect from adverse weather conditions.

13. Where Embankment is to be placed and compacted on slopes that are steeper than 3:1, the subgrade shall be benched to a minimum depth of 6 inches and the Embankment shall be placed in horizontal lifts.

14. Backfilling for Structures and Piping:

    a. All structures, including manholes and pipes shall be backfilled with Embankment as shown in the Contract Drawings and as described in these Specifications.

    b. Where sheeting is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when sheeting is removed. If significant volumes of soil cannot be prevented from clinging to the extracted sheets, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that sheeting will be driven in similar soil conditions or employ other appropriate means to prevent loss of support.

    c. When backfilling around structures, do not backfill until concrete has sufficiently cured (as determined by the CQA Engineer) and is properly supported. Place backfill in a manner to avoid displacement or damage of structures.

TABLE 1: REQUIRED EMBANKMENT PROPERTIES

ITEM	Required % Standard Proctor (ASTM D698)[2]	Required Moisture Content[3]	Maximum Lift Thickness (Compacted) (inches)
Embankment	95	As Required for Compaction	8
Embankment Beneath Structures and Roads[1]	98		8
Backfill Around Structures	95		8
Backfill in Pipe Trenches	95		6
Unclassified Fill	N/A	N/A	N/A

Notes:

1. Embankment beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope. Embankment beneath roads shall be considered to include all embankment placed within 2 vertical feet of the final wearing surface and shall also include shoulders.
2. Determine field density using ASTM D 6938, ASTM D 1556, ASTM D 2167, or ASTM D 2937.
3. Determine field moisture content using ASTM D 6938, ASTM D 2216, ASTM D 4643, or ASTM D 4959.
4. The Engineer may allow exceptions to the above criteria for areas outside of the containment area which are not subject to significant long-term loads.

END OF SECTION

SECTION 02240

GEOTEXTILES

Geotextiles: For the proposed construction, a Type GT-S (Separator/Filter) Geotextile is specified. The Type GT-S Geotextile will be placed in some erosion control and drainage applications.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Geotextiles including all necessary and incidental items as detailed or required for the Contractor to complete the installation in accordance with the Contract Drawings and these Specifications, except as noted below:

a. Geotextiles used as a Silt Fence is covered under Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO) are hereby made a part of these specifications.

ASTM D 3786	Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
AASHTO M 288	Standard Specification for Geotextiles.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each roll of Geotextile shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. The Type GT-S Geotextile shall be a nonwoven spunbonded or nonwoven needlepunched synthetic fabric consisting of polyester or polypropylene manufactured in a manner approved by the Engineer. Woven fabrics may be used in certain applications if approved in advance by the Engineer.

3. All Geotextiles shall conform to the properties listed in Table 1 of this section.

C. SUBMITTALS

Prior to the installation of Geotextiles, the Contractor shall submit the following to the Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for each type of Geotextile attesting that the Geotextiles meet the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of each Geotextile to be used. The samples shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Seaming Procedures:

   Submit proposed seaming procedures including proposed method and equipment.

4. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

   All Geotextiles shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Installation:

   a. The surface receiving the Geotextiles shall be prepared to a relatively smooth condition, free of obstructions, standing water, excessive depressions, debris, and very soft, excessively wet, and/or loose pockets of soil. This surface shall be approved by the Engineer prior to Geotextile placement.

   b. Geotextiles shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, Geotextiles shall be rejected by the Engineer if they have defects, rips, holes, flaws, evidence of deterioration, or other damage.

   c. The Geotextiles shall be placed smooth and free of excessive wrinkles.

   d. On slopes, Geotextiles shall be anchored at the top and unrolled down the slope. In the presence of wind, all Geotextiles shall be weighted with sandbags or other material as approved by the Engineer. Geotextiles uplifted by wind may be reused upon approval by the Engineer.

4. Seams:

a. All Geotextile seams shall be continuously sewn or heat bonded with methods approved by the Engineer. Overlapping of seams may also be allowed if approved in advance by the Engineer. All seams must be approved by the Engineer.

b. On slopes of 6H:1V or steeper, all seams shall be oriented parallel to (in the direction of) the slope unless otherwise approved by the Engineer.

c. Seams to be sewn shall be sewn using a Type 401 stitch. One or two rows of stitching may be used. Each row of stitching shall consist of 4 to 7 stitches per inch. The minimum distance from the geotextile edge to the stitch line nearest to that edge (seam allowance) shall be 1.5 inches if a Type SSa (prayer or flat) seam is used. The minimum seam allowance for all other seam types shall be 1.0 inches.

d. Seams to be heat bonded shall be bonded using hot plate, hot knife, ultrasonic, or other approved devices.

5. Repair Procedures:

Any Geotextile that is torn, punctured, or otherwise damaged shall be repaired or replaced, as directed by the Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of Geotextile placed over the failed areas and shall overlap the existing Geotextile a minimum of 18 inches from any point of the rupture. Patches shall be spot sewn or heat bonded so as not to shift during cover placement.

6. Cover Placement:

Placement of cover over Geotextiles shall be performed in a manner as to ensure that the Geotextiles or underlying materials are not damaged. Cover material shall be placed such that excess tensile stress is not mobilized in the Geotextile.

TABLE 1: REQUIRED GEOTEXTILE PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE[1]
			TYPE GT-S
Geotextile Construction (NW = Nonwoven) (W = Woven)	----------	----------	NW[2] or W[3]
Mass per Unit Area (Unit Weight)	ASTM D 5261	oz/yd^2	N/A
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	70
Strength Class[4]	AASHTO M 288	Class	2
Tensile Properties:	ASTM D 4632		
Grab Strength		lbs	160 (NW) 250 (W)
Grab Elongation		%	$\geq$ 50 (NW) < 50 (W)
Puncture Resistance	ASTM D 4833	lbs	55 (NW) 90 (W)
Trapezoidal Tear Strength	ASTM D 4533	lbs	55 (NW) 90 (W)
Burst Strength	ASTM D 3786	psi	200 (NW) 400 (W)
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70+
Permittivity	ASTM D 4491	sec^{-1}	1.0

Notes:

1. Minimum Average Roll Value (MARV).
2. Nonwoven geotextiles that have been heat calendered are not acceptable, unless approved by the Engineer in advance.
3. Woven geotextiles shall be approved in advance by the Engineer. Woven geotextiles formed exclusively with slit film fibers are not acceptable.
4. AASHTO M 288 criteria includes the above listed requirements for: Tensile Properties, Puncture Resistance, Trapezoidal Tear Strength, and Burst Strength.

END OF SECTION

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SECTION 02258

VEGETATIVE SOIL LAYER

Vegetative Soil Layer (VSL): The Vegetative Soil Layer (VSL) is placed in the final cover system in order to support permanent vegetative cover.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of the VSL for the landfill cover, including borrowing, hauling, spreading, and final grading and all necessary and incidental items as detailed or required to complete the VSL, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Soil Liner	02250

3. Quality Assurance:

Quality Assurance during placement of Vegetative Soil Layer will be provided by the Owner.

B. MATERIALS

Soil that meets all of the following requirements shall be classified as select soil fill for use in construction of the VSL.

1. Soil materials used in the VSL shall be reasonably free of gypsum, ferrous, and/or calcareous concretions and nodules, refuse, roots, or other deleterious substances.

2. The VSL shall be uniform, smooth, and free of debris, rock, plant materials, and other foreign material larger than 3 inches in diameter. The material should contain no sharp edges. This material must be capable of supporting growth of vegetative cover.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer:

1. Before approval is given to proceed, the Contractor shall submit descriptive information on placement equipment to be used in construction of the VSL.

D. CONSTRUCTION

1. All placement and compaction of VSL shall be performed only when the CQA Engineer is informed by the Contractor of intent to perform such work.

2. VSL shall be placed as specified below:

   a. The VSL, including topsoil, shall be placed and spread using tracked equipment. The CQA Engineer shall approve the equipment used to place the VSL.

   b. VSL shall be placed and compacted to the lines and grades shown on the Contract Drawings with the exception that a 0.15 foot overbuild at Contractor's expense is allowed. The Contractor will perform all surveys necessary to establish and verify lines and grades for all VSL.

   c. VSL shall be compacted by tracking the final lift with tracked equipment.

3. After the specified thickness has been achieved and verified, the Contractor shall proceed immediately with seeding.

4. Surveying:

   After completion of a segment of VSL, the VSL shall be surveyed (by test pit or hand auger) on a 100 foot grid to ensure the minimum specified thickness of VSL has been achieved.

END OF SECTION

SECTION 02270

EROSION AND SEDIMENTATION CONTROL

Erosion and Sedimentation Control: Erosion and Sedimentation Control is a system of construction and engineered measures (devices, structures, practices, etc.) which act to minimize surface water induced erosion of disturbed areas and the resulting off-site sedimentation.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of and maintain Erosion and Sedimentation Control measures and related work in accordance with the Contract Drawings and these Specifications.

All Erosion and Sedimentation Control work shall be in accordance with the latest edition of the North Carolina Erosion and Sediment Control Planning and Design Manual as well as applicable regulations.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Geotextiles	02240
Rip Rap	02271
Rolled Erosion Control Products	02275
Storm Water Systems	02720
Revegetation	02930

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

ASTM D 3786 Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

B. MATERIALS

1. Permanent Sediment or Detention Basins:

Permanent sediment or detention basins shall be constructed as shown on the Contract Drawings.

2. Permanent Drainage Channels, Diversions, Swales, and Ditches:

Permanent drainage channels, diversions, swales, and ditches shall be constructed as shown on the Contract Drawings.

3. Silt Fence:

Silt fences shall be constructed as shown on the Contract Drawings and as needed, based on the Contractor's discretion and Engineer's approval. The silt fence is a permeable barrier erected within and downgradient of small disturbed areas to capture sediment from sheet flow. It is made of filter fabric buried at the bottom, stretched, and supported by posts and wire mesh backing. Silt fence shall conform to the following properties:

a. Posts: Posts shall be 1.33 lb/linear foot steel (preferred) or wood with a minimum length of 5 feet. Steel posts shall be "U" or "T"-type. Wood posts shall have a minimum diameter of 4-inches.

b. Filter Fabric: Filter fabric shall be a woven geotextile made specifically for sediment control. Filter fabric shall conform to the properties listed in Table 1 of this section.

4. Geotextiles:

Geotextiles shall conform to the requirements of Section 02240, Geotextiles, of these Specifications.

5. Filter Berms:

Filter berms shall be constructed as shown on the Contract Drawings.

6. Down Chutes and Pipes:

Down chutes and pipes shall be constructed as shown on the Contract Drawings.

7. Rip Rap:

Rip Rap shall conform to the requirements of Section 02271, Rip Rap, of these Specifications.

8. Rolled Erosion Control Products (RECPs):

Rolled Erosion Control Products (RECPs) shall conform to the requirements of Section 02275, Rolled Erosion Control Products, of these Specifications.

9. Other Work:

In addition to the Erosion and Sedimentation Control measures shown on the Contract Drawings, the Contractor shall provide adequate means to prevent any sediment from entering any storm drains, drop inlets, ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of off-site areas. In areas where a natural buffer area exists between the work area and the closest stream or water course, this area shall not be disturbed. All paved areas shall be scraped and swept as necessary to prevent the accumulation of dirt and debris. Work associated with this provision shall be considered incidental to the project and no separate payment will be made.

10. Temporary and Permanent Ground Cover:

The Contractor shall provide temporary or permanent ground cover (or other acceptable measure(s)) adequate to restrain erosion on erodible slopes or other areas within 21 calendar days following completion of any phase of grading. The

Contractor shall provide permanent ground cover for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following the completion of construction.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Erosion and Sedimentation Control materials manufactured for the project have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Establishment of Erosion and Sedimentation Control Measues:

   a. All Erosion and Sedimentation Control measures will be constructed according to the Contract Drawings and these Specifications.

   b. Due to the nature of the work required by this Contract, it is anticipated that the location and nature of the Erosion and Sedimentation Control measures may need to be adjusted on several occasions to reflect the current phase of construction.

   c. Erosion and Sedimentation Control measures shall be established prior to the work in a given area. Where such practice is not feasible, the Erosion and Sedimentation Control measure(s) shall be established immediately following completion of the clearing operation.

   d. The construction schedule adopted by the Contractor will impact the placement and need for specific measures required for the control of erosion. The Contractor shall develop and implement such additional techniques as may be required to minimize erosion and prevent or correct the discharge of sediment outside the limits of construction (unless controlled by other on-site measure(s)).

   e. The location and extent of Erosion and Sedimentation Control measures shall be revised at each phase of construction that results in a change in either the quantity or direction of surface runoff from construction areas. All deviations from the control provisions shown on the Contract Drawings shall have the prior approval of the Engineer.

2. Inspection and Maintenance of Erosion and Sedimentation Control Measures:

a. The Contractor shall furnish the labor, material, and equipment required for the inspection and maintenance of all Erosion and Sedimentation Control measures. Maintenance shall be scheduled as required for a particular measure to maintain the removal efficiency and intent of the measure.

b. All Erosion and Sedimentation Control measures shall be inspected at least once every seven calendar days and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period and appropriate maintenance conducted. A rain gauge shall be maintained on the site and a record of the rainfall amounts and dates shall be kept properly.

c. Maintenance shall include, but not be limited to:

(1) The removal and satisfactory disposal of trapped or deposited sediments from basins, traps, barriers, filters, and/or drainage features/devices;

(2) Replacement of filter fabrics used for silt fences upon loss of efficiency; and

(3) Replacement of any other components which are damaged or cannot serve the intended use.

d. The Contractor shall accept and maintain any existing sediments that are included in existing sediment traps or basins that accept or will accept stormwater flow and or sediment accumulation from all areas within the Contractor's limits of construction.

e. Sediments removed from Erosion and Sedimentation Control measures shall be disposed of in locations that will not result in off-site sedimentation as approved by the Engineer.

f. All Erosion and Sedimentation Control measures shall be maintained to the satisfaction of the Engineer until the site has been stabilized.

3. Finish Grading:

All disturbed areas shall be uniformly graded to the lines, grades, and elevations shown on the Contract Drawings. Finished surfaces shall be reasonably smooth, compacted, and free from irregular surface changes. Unless otherwise specified, the degree of finish shall be that ordinarily obtainable from either blade or scraper

operations. Areas shall be finished to a smoothness suitable for application of topsoil.

4. Revegetation:

Revegetation shall conform to the requirements of Section 02930, Revegetation, of these Specifications.

5. Cleanup:

a. The Contractor shall remove from the site all subsoil excavated from his work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

b. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

TABLE 1: REQUIRED SILT FENCE FILTER FABRIC PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE[1]
Grab Tensile Strength[2]	ASTM D 4632	lbs	100 x 100
Grab Elongation	ASTM D 4632	%	20 (Max.)
Trapezoidal Tear Strength[2]	ASTM D 4533	lbs	65 x 65
Burst Strength	ASTM D 3786	psi	300
Puncture Resistance	ASTM D 4833	lbs	65
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	80
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	30+
Permittivity	ASTM D 4491	sec^{-1}	0.05

Notes:
1. Minimum Average Roll Value (MARV).
2. Values for machine and cross machine direction (MD x XD), respectively.

END OF SECTION

SECTION 02271

RIP RAP

Rip Rap: This section includes all rip rap aprons and channel protection.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Rip Rap for protection of earthen slopes against erosion as indicated, including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Geotextiles	02240
Erosion and Sedimentation Control	02270

3. Reference Standards:

The latest revision of the following standards of the North Carolina Department of Transportation (NCDOT) are hereby made a part of these Specifications.

NCDOT Standard Specifications for Roads and Structures.

B. MATERIALS

1. Rip Rap: Rip Rap shall be of the size indicated on the Contract Drawings and shall conform to NCDOT Section 1042, Rip Rap Materials.

2. Geotextiles: Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results prior to installation, that all Rip Rap has been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Surface Preparation:

   a. Trim and dress all areas to conform to the Contract Drawings as indicated with tolerance of 2 inches from theoretical slope lines and grades.

   b. Bring areas that are below allowable minimum tolerance limit to grade by filling with compacted Embankment material similar to adjacent material.

   c. Geotextiles shall be placed as shown on the Contract Drawings and in accordance with Section 02240, Geotextiles, of these Specifications.

   d. Do not place any stone material on the prepared surface prior to inspection and approval to proceed from the Engineer.

2. Placing Rip Rap:

   Rip Rap shall be placed in accordance with NCDOT Section 868, Rip Rap.

END OF SECTION

SECTION 02275

ROLLED EROSION CONTROL PRODUCTS

Rolled Erosion Control Products: Rolled Erosion Control Products (RECPs) include erosion control blankets (ECB) and turf reinforcement mats (TRM) placed in channels and on slopes.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of all RECPs in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
Revegetation	02930

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

ASTM D 4355 Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

ASTM D 6475 Standard Test Method for Measuring Mass per Unit Area of Erosion Control Blankets.

ASTM D 6524 Standard Test Method for Measuring the Resiliency of Turf Reinforcement Mats.

ASTM D 6525 Standard Test Method for Measuring Nominal Thickness of Permanent Erosion Control Products.

ASTM D 6566	Standard Test Method for Measuring Mass per Unit Area of Turf Reinforcement Mats.
ASTM D 6818	Standard Test Method for Ultimate Tensile Properties of Turf Reinforcement Mats.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each RECP shall identify the length, width, product name, and name of Manufacturer.

2. Erosion Control Blanket (ECB):

ECB shall consist of a machine-produced mat of straw or wood excelsior fiber covered on the top side with a photodegradable extruded plastic or woven biodegradable netting and sewn together with degradable thread. ECB shall also conform to the properties listed in Table 1 of this section. ECB shall be S75, as manufactured by North American Green, CURLEX I, as manufactured by American Excelsior Company, LANDLOK S1, as manufactured by Propex Fabrics, or approved equal.

3. Turf Reinforcement Mat (TRM):

TRM shall consist of a dense web of crimped and interlocking polypropylene fibers positioned between two biaxially oriented nets and mechanically bound together by parallel stitching with polypropylene thread. TRM shall be designed to accelerate seedling emergence, exhibit high resiliency, and possess strength and elongation properties to limit stretching in a saturated condition. TRM shall be stabilized against chemical and UV degradation which are normally found in a natural soil environment and shall have no biodegradable components. TRM shall also conform to the properties listed in Table 1 of this section. TRM shall be LANDLOK TRM 435, as manufactured by Propex Fabrics, or approved equal.

4. Anchors: Anchors for RECPs shall consist of machine made staples of No. 8 gauge new steel wire formed into a "U" shape. The size when formed shall be not less that 8 inches in length with a throat of not less than 1 inch in width. Longer anchors may be required for loose soils. Other anchors, such as metal pins or plastic pegs, may also be used if approved in advance by the Engineer.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for each RECP attesting that each RECP meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of each RECP to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Installation Guidelines/Instructions: The Manufacturer's guidelines/instructions for installation shall be submitted for review.

4. Furnish copies of delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

   All RECPs shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Installation - General:

   a. Placing of RECPs shall be done immediately following seeding. Seeding shall be performed in accordance with Section 02930, Revegetation, of these Specifications.

   b. RECPs shall be placed to the lines and grades shown on the Contract Drawings. The earth surface shall be smooth and free from stones, clods, or debris which will prevent the contact of the RECP with the soil. Care shall be taken to preserve the required line, grade, and cross section of the area.

   c. RECPs shall be unrolled in the direction of the flow of water and shall be applied without stretching so that it will lie smoothly but loosely on the soil surface.

   d. At the time of installation, RECPs shall be rejected, if they have defects, rips, holes, flaws, evidence of deterioration, or other damage.

e. The Engineer may require adjustments in the installation requirements to fit individual conditions.

3. Installation - Channels:

RECPs installed in channels shall be unrolled parallel to the direction of water flow. The first roll shall be centered longitudinally in the channel and anchored with staples. Subsequent rolls shall be installed outward to the edges of the channel and be lapped to allow installation of a common row of anchors. RECP ends shall be overlapped with the upstream ends on top ("shingled"). Refer to the Contract Drawings and/or the Manufacturer's installation guidelines/instructions for installation details.

4. Installation - Slopes:

RECPs installed on slopes shall be oriented in vertical strips and anchored. Subsequent rolls shall be installed outward to the edge(s) of the original roll and be lapped to allow installation of a common row of anchors. RECP ends shall be shingled. Refer to the Contract Drawings and/or the Manufacturer's installation guidelines/instructions for installation details.

5. Maintenance:

Maintenance of RECPs shall be in accordance with Section 02270, Erosion and Sedimentation Control, of these Specifications.

TABLE 1: REQUIRED ROLLED EROSION CONTROL PRODUCT PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE[1]
Erosion Control Blanket (ECB)			
Mass per Unit Area	ASTM D 6475	lbs/yd^2	0.5 ± 10% (Straw) 0.7 ± 10% (Excelsior)
Tensile Strength[2]	ASTM D 6818	lbs/ft	50 x 65
Tensile Elongation	ASTM D 6818	%	20
Maximum Permissible Shear Stress (Un-Vegetated)	-----	lb/ft^2	1.55
Functional Longevity	-----	months	12
Turf Reinforcement Mat (TRM)			
Mass per Unit Area	ASTM D 6566	oz/yd^2	8
Thickness	ASTM D 6525	inches	0.35
Tensile Strength[2]	ASTM D 6818	lbs/ft	225 x 175
Tensile Elongation	ASTM D 6818	%	50 (max.)
Resiliency	ASTM D 6524	%	80
UV Resistance (1,000 Hours)	ASTM D 4355	%	80
Maximum Permissible Shear Stress (Long-Term Vegetated)	Large Scale	lb/ft^2	5

Notes:

1. Typical for ECB; Minimum Average Roll Value (MARV) for TRM.
2. Values for machine and cross machine direction (MD x XD), respectively.

END OF SECTION

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SECTION 02712

DRAINAGE GEOCOMPOSITE

Drainage Geocomposite (DGC): The Drainage Geocomposite (DGC) consists of a geonet drainage core and heat-bonded nonwoven geotextile. The purpose of the DGC is to rapidly transmit flow to collection piping.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of DGC, including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Vegetative Soil Layer	02258
LLDPE Geomembrane	02778
Geosynthetic Clay Liner	02776
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the Geosynthetic Research Institute (GRI) are hereby made a part of these specifications.

ASTM D 413	Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.

ASTM D 4218	Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique.
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
ASTM D 6243	Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
GRI GC7	Determination of Adhesion and Bond Strength of Geocomposites.

4. Quality Control:

The Contractor shall perform Quality Control tests in accordance with Table 3 of this section.

5. Quality Assurance:

Quality Assurance during installation of DGC will be provided by the Owner as described in the accompanying Project CQA Manual.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each roll of DGC shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. The geonet drainage core shall be manufactured by extruding polyethylene strands to form a three dimensional structure to provide planer water flow.

3. A nonwoven needlepunched geotextile, consisting of polyester or polypropylene and manufactured in a manner approved by the Engineer, shall be heat-bonded to the geonet drainage core. Roll edges shall have a maximum unbonded length of 6 inches, unless otherwise approved by the Engineer. Heat bonding shall be performed by the Manufacturer prior to shipping to the site.

4. The geonet drainage core shall contain UV inhibitors to prevent ultraviolet light degradation.

5. Final Cover Drainage Geocomposite:

Final Cover DGC shall have a nonwoven geotextile heat-bonded to both sides of the geonet drainage core. Physical properties of the DGC shall be as shown in Table 1 of this section.

C. SUBMITTALS

Prior to DGC installation, the Contractor shall submit the following to the CQA Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the DGC attesting that the DGC meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall

also submit a sample of the DGC to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Seaming Procedures:

   Submit proposed seaming procedures including proposed method and equipment.

4. Quality Control Certificates: For DGC delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of DGC. Each certification shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section.

5. Contractor Quality Control Test Results: The Contractor shall provide the results of required testing.

6. Furnish copies of delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

   All DGC shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

   DGC that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and quality assurance testing of DGC supplied as replacement for rejected material shall be performed by the CQA Engineer at Contractor's cost.

3. Installation:

   a. The DGC shall be placed only on Geomembrane that has been approved by the Geomembrane Installer and accepted by the CQA Engineer. The Contractor shall remove debris, including sediment to the degree possible, from the Geomembrane prior to placement of the DGC.

b. DGC shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, the DGC shall be rejected, if it has defects, rips, holes, flaws, evidence of deterioration, or other damage. Isolated areas of up to 1 square yard where the geotextile has become delaminated from the geonet drainage core may be allowed by the CQA Engineer as long as there appears to be a good bond between the geotextile and the geonet in surrounding areas. Rolls where the geotextile appears to be easily delaminated from the geonet such as by foot or ATV traffic shall be rejected.

c. Orientation: If the DGC transmits flow in a predominant direction (typically along the roll length), then the DGC shall be installed with the predominant flow direction laid approximately perpendicular to contour lines (i.e. in the direction of the slope) or as specified by the Engineer. Otherwise, DGC shall be installed with the machine direction (along the roll length) generally in the direction of flow or as specified by the Engineer.

d. The DGC shall be placed smooth and free of excessive wrinkles.

e. The Contractor shall provide temporary anchorage of the DGC at the top of perimeter and interior berms during installation as necessary to prevent movement during construction. Such anchorage may include sandbags and the like, as approved by the CQA Engineer. Permanent bonding to the Geomembrane shall be prohibited.

4. Seams:

a. All seams constructed on slopes of 6H:1V or steeper or within 10 feet of the toe of a slope of 6H:1V or steeper shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer. Where allowed by the Engineer, end seams on slopes of 6H:1V or steeper shall be staggered a minimum of 5 feet between adjacent rolls.

b. Geonet Drainage Core: The geonet drainage core shall be laid with a 3 inch minimum overlap seam along roll edges and a 6 inch minimum overlap seam along roll ends and shall be secured using plastic ties. Ties shall be placed every 5 feet along roll edges; every 12 inches along roll ends; and every 6 inches in the anchor trench.

c. Geotextile Component(s): Where applicable, the bottom geotextile of the DGC shall be overlapped with the same of the adjacent rolls. The top geotextile of the DGC shall be continuously sewn or heat bonded to the same of the adjacent rolls with methods approved by the Engineer.

(1) Seams to be sewn shall be sewn using a Type 401 stitch. One or two rows of stitching may be used. Each row of stitching shall consist of 4 to 7 stitches per inch. The minimum distance from the geotextile edge to the stitch line nearest to that edge (seam allowance) shall be 1.5 inches if a Type SSa (prayer or flat) seam is used. The minimum seam allowance for all other seam types shall be 1.0 inches.

(2) Seams to be heat bonded shall be bonded using hot plate, hot knife, ultrasonic, or other approved devices.

5. Repairs:

Any DGC that is torn, crushed, punctured, or otherwise damaged shall be repaired or replaced, as directed by the CQA Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of material, placed over the damaged area and shall overlap the existing material a minimum of 12 inches from any point of the damage. The patch shall be connected to the geonet drainage core of the damaged material using plastic cable ties at a 6 inch spacing and the upper geotextile of the patch shall be spot sewn or heat bonded to the upper geotextile of the damaged material. A geotextile patch, spot sewn or heat bonded to the damaged material, may be used where damage is to only that portion of the DGC.

6. Cover Placement:

Placement of materials over DGC shall be performed in a manner as to ensure that DGC and the underlying geosynthetics are not damaged; minimal slippage of DGC on the underlying geosynthetics occurs; no excess tensile stresses occur in the DGC; and that no portion of the DGC develops excessive wrinkles or crimp. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and covering methods or DGC that becomes crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

TABLE 1: REQUIRED DRAINAGE GEOCOMPOSITE PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE
Geonet:			
Thickness	ASTM D 5199	inches	0.25 (See Note 1)
Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 1603/D 4218	%	2-3
Geotextile:			
Mass per Unit Area (Unit Wt.)	ASTM D 5261	oz/yd^2	6
Tensile Properties:	ASTM D 4632		
Grab Strength		lbs	160
Grab Elongation		%	$\geq$ 50
Puncture Resistance	ASTM D 4833	lbs	55
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70+
Permittivity	ASTM D 4491	sec^{-1}	1.0
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	70
Geocomposite:			
Ply Adhesion	ASTM D 413/ GRI GC7	lb/inch	2.0 Typ. 1.0 Min. Avg.
Transmissivity: (Final Cover)	ASTM D 4716	$m^3/m/sec$	8.0×10^{-4} (See Note 2)
Interface Shear Strength (Peak)[3, 4] (Final Cover)	ASTM D 5321 ASTM D 6243 (GCL)	psf	55 psf (Load = 200 psf)

Notes:

1. A thicker geonet may be required depending on transmissivity requirements.
2. Final Cover:
   Conduct test for transmissivity at a normal compressive load of 1,000 psf and at a hydraulic gradient of 0.10 after a seating period of at least 24 hours. Boundary

conditions are soil (sand) interface on the upper geotextile and textured LLDPE geomembrane (or GCL) against the lower geotextile.

3. DGC shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
4. The specified interface shear strength requirement is based on a finished slope no steeper than 6H:1V. Steeper slopes will require evaluation by the Engineer.

TABLE 2: REQUIRED MANUFACTURER QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Geonet:		
Thickness	ASTM D 5199	50,000 ft^2
Density	ASTM D 1505	50,000 ft^2
Carbon Black Content	ASTM D 1603/D 4218	50,000 ft^2
Geotextile:		
Mass Per Unit Area	ASTM D 5261	200,000 ft^2
Tensile Properties	ASTM D 4632	200,000 ft^2
Puncture Resistance	ASTM D 4833	200,000 ft^2
Apparent Opening Size (AOS)	ASTM D 4751	600,000 ft^2
Permittivity	ASTM D 4491	600,000 ft^2
UV Resistance	ASTM D 4355	600,000 ft^2
Geocomposite:		
Ply Adhesion	ASTM D 413/ GRI GC7	100,000 ft^2
Transmissivity[1]	ASTM D 4716	100,000 ft^2 (See Note 2)

Notes:

1. Conduct transmissivity tests in accordance with the criteria given in Table 1.
2. The required Manufacturer's quality control testing for transmissivity may be reduced to one test per resin lot or one test per 500,000 ft^2 (whichever provides

the larger number of tests) if the minimum measured transmissivity is at least 50% greater than specified.

TABLE 3: REQUIRED CONTRACTOR QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Interface Shear Strength	ASTM D 5321 ASTM D 6243 (GCL)	(See Note 1)

Notes:

1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:

   A. Textured LLDPE-GM (30 mil) or GCL against existing cover soils (intermediate cover);
   B. Drainage Geocomposite against textured LLDPE-GM (30 mil) or GCL; and
   C. Vegetative Soil Layer against Drainage Geocomposite.

   If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping. Upon review of test results, the Engineer may allow exceptions to the above criteria.

   For tests involving textured geomembranes, the laboratory shall also report the asperity height (GRI GM12) for the material samples used in the actual direct shear tests.

END OF SECTION

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SECTION 02720

STORM WATER SYSTEMS

Storm Water Systems: Storm Water Systems shall include all piping, pipe fittings, flared end sections, drop inlets, manholes, and other appurtenances designated to convey stormwater.

A. DESCRIPTION

1. General:

The contractor shall furnish all labor, material, and equipment to complete installation of Storm Water Systems in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
Rip Rap	02271

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), and the North Carolina Department of Transportation (NCDOT) are hereby made a part of these specifications.

ASTM C 76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
ASTM C 150	Standard Specification for Portland Cement.
ASTM D 1248	Standard Specification for Polyethylene Plastics Molding and Extrusion Materials For Wire and Cable.
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

ASTM D 3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
AASHTO M 36	Specification for Corrugated Steel Pipe.
AASHTO M 252	Specification for Corrugated Polyethylene Drainage Tubing, 3 to 10 Inch Diameter.
AASHTO M 294	Specification for Corrugated Polyethylene Pipe, 12 to 36 Inch Diameter.
NCDOT	Standard Specifications for Roads and Structures and Roadway Standard Drawings.

B. MATERIALS

1. Reinforced Concrete Pipe (RCP):

a. All reinforced concrete pipe shall be manufactured in accordance with ASTM C 76, Wall Type B or C, and shall be of the class that equals or exceeds the pipe class as shown on the Contract Drawings. All pipe shall be aged at the manufacturing plant for at least fourteen (14) days before delivery to the job site.

b. Minimum pipe laying lengths shall be four (4) feet.

c. Joints for reinforced concrete pipe shall have tongue and groove or bell and spigot ends with leak-resistant mastic joint sealant. Joint sealant shall be ConSeal type, or approved equal.

2. Corrugated Metal Pipe (CMP):

a. Corrugated metal pipe and fittings shall be of the sizes shown or specified and shall conform to every aspect of AASHTO M 36.

b. Corrugated metal pipe shall be fabricated from galvanized steel sheets. Corrugation profile shall be 2⅔ inch crest to crest and ½ inch crest to valley, and sheet thickness shall be 16 gage/.064 inch minimum.

c. Pipe sections shall be helically corrugated with each pipe end rerolled to obtain no less than two (2) annular corrugations.

d. Coupling Bands: CMP shall be firmly joined by coupling bands in accordance with the manufacturer's recommendations. These bands shall

be not more than two nominal sheet thicknesses lighter than the thickness of the pipe to be connected and in no case lighter than 0.052 inches.

e. All CMP utilized for permanent installation shall have gasketed joints.

f. Asphaltic or bituminous coatings shall be applied in conformance with the manufacturer's requirements, as applicable.

3. Corrugated Polyethylene (CPE) Pipe:

CPE pipe and fittings shall be of the sizes and type shown on the Contract Drawings and shall conform to every aspect of AASHTO M 252 (3 to 10 inch diameters) or AASHTO M 294 (12 to 36 inch diameters). All Type S CPE pipe shall have watertight joints.

4. Flared End Sections:

Flared end sections shall be reinforced and shall be fabricated from the same materials meeting the same requirements as the pipe to which they are connected. All reinforced concrete and corrugated metal flared end sections shall meet the requirements of the NCDOT. Corrugated polyethylene flared end sections shall be as recommended by the pipe manufacturer.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Storm Water Systems have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. All piping shall be installed by skilled workmen and in accordance with the best standards for piping installation. Proper tools and appliances for the safe and convenient handling and installation of the pipe and fittings shall be used.

2. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be defective. If any defective piece should be discovered after having been installed, it shall be removed and replaced at the Contractor's expense.

3. Excavation and backfilling of pipe trenches shall be as described in Section 02222, Excavation and Section 02223, Embankment, respectively, of these Specifications.

4. Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. No materials shall be dropped or dumped into the trench.

5. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fittings, or valves. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored as required.

6. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade.

7. The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings. Before joints are made, each pipe shall be well bedded on a solid foundation. No pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid by the Contractor at his own expense.

8. The laying of reinforced concrete pipe shall conform to the current recommendations of the American Concrete Pipe Association for Installation Type 1 or 2.

END OF SECTION

SECTION 02776

GEOSYNTHETIC CLAY LINER (GCL)

Geosynthetic Clay Liner (GCL): The GCL serves as the primary hydraulic barrier within the final cover system.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of GCL in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Drainage Geocomposite	02712
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

ASTM D 5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.
ASTM D 5890	Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
ASTM D 5891	Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.
ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.

ASTM D 6243	Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
ASTM D 6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
ASTM D 6768	Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.

4. Quality Control:

The Contractor shall perform Quality Control tests in accordance with Table 3 of this section.

5. Quality Assurance:

Quality Assurance during installation of GCL will be provided by the Owner as described in the accompanying Project CQA Manual.

6. Manufacturer Qualifications:

The GCL shall be furnished by a Manufacturer that has previously produced a minimum of 10,000,000 square feet of the material for use in similar projects.

7. Warranties:

a. General: Should a defect occur, which is covered under warranty, the Warrantor shall bear all costs for repair and/or relocation and replacement of the GCL.

b. Workmanship: The Contractor shall furnish the Owner a warranty from the GCL Installer which warrants their workmanship to be free of defects on a prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to overlapped seams, anchor trenches, attachments to appurtenances, and penetration seals, as applicable.

c. Manufacturer's Warranty: The Contractor shall furnish the Owner a warranty from the GCL Manufacturer for the materials used. The material warranty shall be for defects or failures related to manufacture on a prorata basis for five (5) years after date of shipment.

B. MATERIALS

1. General:

The GCL shall consist of bentonite encased, top and bottom, with 6 oz./square yard non-woven geotextiles needle-punched together for reinforcement. GCL with a lighter non-woven geotextile or a woven geotextile on one side may be considered by the Engineer as long as all other criteria are met. Needle-punched GCL shall be essentially free of broken needles and fragments of needles that would negatively effect the performance of the final product. The materials supplied under these Specifications shall be first quality products designed and manufactured specifically for the purposes of this work.

The GCL shall be supplied in rolls which have a minimum width of 14 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest overlaps. Labels on the roll shall identify the length, width, lot and roll numbers, name of Manufacturer, proper direction of unrolling, and minimum recommended overlap.

2. Needle Detection and Removal Procedures:

The GCL Manufacturer shall use continuous needle detection and removal devices (e.g. metal detectors and magnets) in the manufacture of needle-punched GCL.

3. Physical Properties:

Physical properties of GCL shall be as shown in Table 1 of this section.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer:

1. Pre-Installation Requirements:

Prior to GCL installation, the Contractor shall submit the following:

a. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the GCL attesting that the GCL meets the physical and manufacturing requirements stated in these Specifications including needle detection and removal procedures. The Contractor shall also submit a sample of the GCL to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

b. Qualifications:

(1) Submit list of equipment and personnel proposed for the Project. Include equipment type and quantities. Include personnel experience on similar projects.

(2) Submit resume and references of Installation Supervisor to be assigned to the Project, including data and duration of employment and pertinent experience information.

c. Shipping, Handling, and Storage Instructions: The Manufacturer's recommendations for shipping, handling, and storage shall be submitted for review.

d. Delivery Date: Submit notification of the scheduled delivery date for the materials.

e. Installation Procedures and Drawings:

Submit installation procedures and (shop) drawings for carrying out the work. Procedures addressed by the Contractor shall include but not be limited to material installation, repair, and protection to be provided in the event of rain. Submit drawings showing typical details including pipe penetrations (if applicable). Following review, these procedures and drawings will be used for installation of the GCL. Any deviations from these procedures and drawings must be approved by the Engineer and CQA Engineer.

f. Quality Control Certificates: For GCL delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of GCL. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section. Each certificate shall also include a certification that each roll of GCL has been continually checked by the Manufacturer for needles and that any needles detected have been removed.

g. Contractor Quality Control Test Results: The Contractor shall provide the results of required testing.

h. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

2. Post-Installation Requirements:

Upon completion of GCL installation the Contractor shall submit the following:

a. A certificate stating that the GCL has been installed in accordance with the Drawings, Specifications, and the Manufacturer's recommendations.

b. Completed Manufacturer's and Workmanship Warranties.

Finalization of payment for GCL installation shall not be made until the above submittals have been reviewed by the CQA Engineer.

D. CONSTRUCTION

1. Shipping , Handling, and Storage:

The GCL shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

GCL that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and CQA testing of GCL supplied as replacement for rejected material shall be performed by the CQA Engineer at Contractor's cost.

3. Installation of GCL:

a. The surface receiving the GCL shall be prepared to a relatively smooth condition, free of obstructions, standing water, excessive depressions, debris, and very soft, excessively wet, and/or loose pockets of soil. This surface shall be approved by the CQA Engineer prior to GCL placement.

b. GCL shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, GCL shall be rejected by the CQA Engineer if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.

c. The GCL shall not be placed during precipitation. Any material that becomes hydrated shall be removed and replaced at Contractor expense.

d. The GCL shall be placed smooth and free of excessive wrinkles.

e. Where horizontal seams are required on sloped surfaces, the panels shall be placed such that the "upstream" panel forms the upper panel and

overlaps the "downstream" panel in order to minimize infiltration potential. All seams constructed on slopes of 6H:1V or steeper shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer.

f. All vertical panels placed on slopes of 6H:1V or steeper shall extend a minimum of 5 feet beyond the grade break with a slope flatter than 6H:1V.

g. The GCL shall be laid with a 6 inch minimum overlap seam along roll edges and a 12 inch minimum overlap seam along roll ends. Granular sodium bentonite shall be added between all overlapped seams at a rate of approximately 0.25 lbs/linear foot. As an alternative to the addition of bentonite along roll edges, GCL with slits cut in one of the geotextiles may be used if approved in advance by the Engineer.

h. GCL shall be temporarily secured in a manner approved by the CQA Engineer prior to placement of overlying materials.

i. Any GCL that is torn, punctured, or otherwise damaged shall be repaired or replaced as directed by the CQA Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of GCL placed over the damaged areas and shall overlap the existing GCL a minimum of 12 inches from any point of the damage.

j. GCL shall be covered with the overlying materials or otherwise protected from hydration due to rainfall (i.e. temporary tarps, scrap geomembrane, etc.) within 24 hours of GCL placement, or sooner if rain is imminent.

k. Penetrations: All penetrations of GCL shall be made in accordance with the Contract Drawings and/or as directed by the Engineer.

4. Cover Placement:

Placement of materials over GCL shall be performed in a manner as to ensure that GCL and the underlying geosynthetics are not damaged; minimal slippage of GCL on the underlying geosynthetics occurs; no excess tensile stresses occur in the GCL; and that no portion of the GCL develops excessive wrinkles or crimp. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and covering methods or GCL that becomes crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

TABLE 1: REQUIRED GCL PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE
Clay:			
Bentonite Swell Index	ASTM D 5890	ml/2g	24
Bentonite Fluid Loss	ASTM D 5891	ml	≤ 18
GCL:			
Bentonite Content	ASTM D 5993	psf	0.75 (@ 0% moisture)
Tensile Strength	ASTM D 6768	lbs/in	30
Peel Strength	ASTM D 6496	lbs/in	5.3 Min. Avg.
Hydraulic Conductivity	ASTM D 5887	cm/sec	$\leq 5 \times 10^{-9}$
Internal Shear Strength[1] (Hydrated) (Peak)	ASTM D 6243	psf	500
Interface Shear Strength (Hydrated) (Peak)[2, 3]	ASTM D 6243	psf	55 psf (Load = 200 psf)

Notes:

1. Peak value measured at a normal load of 200 psf after a minimum 24 hour hydration period.
2. GCL shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
3. The specified interface shear strength requirement is based on a finished slope no steeper than 6H:1V. Steeper slopes will require evaluation by the Engineer.

TABLE 2: REQUIRED MANUFACTURER QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Clay:		
Bentonite Swell Index	ASTM D 5890	50 tons
Bentonite Fluid Loss	ASTM D 5891	50 tons
GCL:		
Bentonite Content	ASTM D 5993	5,000 yd^2
Tensile Strength	ASTM D 6768	25,000 yd^2
Peel Strength[1]	ASTM D 6496	5,000 yd^2
Hydraulic Conductivity	ASTM D 5887	30,000 yd^2
Internal Shear Strength[2] (Hydrated)	ASTM D 6243	Periodic

Notes:

1. Conduct peel strength tests in accordance with the criteria given in Table 1.
2. Conduct shear strength tests in accordance with the criteria given in Table 1.

TABLE 3: REQUIRED CONTRACTOR QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Interface Shear Strength	ASTM D 6243	(See Note 1)

Notes:

1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:

   A. Textured LLDPE-GM (30 mil) or GCL against existing cover soils (intermediate cover);
   B. Drainage Geocomposite against textured LLDPE-GM (30 mil) or GCL; and
   C. Vegetative Soil Layer against Drainage Geocomposite.

   If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping. Upon review of test results, the Engineer may allow exceptions to the above criteria.

   For tests involving textured geomembranes, the laboratory shall also report the asperity height (GRI GM12) for the material samples used in the actual direct shear tests.

END OF SECTION

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SECTION 02778

LLDPE GEOMEMBRANE

LLDPE Geomembrane (LLDPE-GM): The LLDPE Geomembrane serves as the primary hydraulic barrier in the final cover system.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of LLDPE-GM including all necessary and incidental items as detailed or required to complete the installation in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Vegetative Soil Layer	02258
Drainage Geocomposite	02712
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the Geosynthetic Research Institute (GRI) are hereby made a part of these Specifications.

ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.

ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
GRI GM9	Cold Weather Seaming of Geomembranes.
GRI GM12	Asperity Measurement of Textured Geomembranes Using a Depth Gage.
GRI GM17	Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.
GRI GM19	Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

4. Quality Control:

   a. The Contractor shall perform Quality Control tests in accordance with Table 2 of this section.

   b. The Geomembrane Installer shall follow the procedures and requirements described in the accompanying Project CQA Manual during installation of

LLDPE-GM including performing and documenting trial seams, nondestructive and destructive Quality Control tests, and repairs.

5. Quality Assurance:

Quality Assurance during installation of LLDPE-GM will be provided by the Owner as described in the accompanying Project CQA Manual.

6. Manufacturers Qualifications:

The Manufacturer shall have previously demonstrated his ability to produce the required LLDPE-GM by having successfully manufactured a minimum of 5,000,000 ft^2 of LLDPE-GM for hydraulic containment purposes.

7. Installer Qualifications:

a. Installation of the LLDPE-GM shall be performed by an Installer that has installed a minimum of 5,000,000 ft^2 of LLDPE-GM (or similar material) within the past five (5) years in similar landfill installations.

b. All Installation Supervisors assigned to the Project shall have previously managed the installation of at least 2,000,000 ft^2 of LLDPE-GM (or similar material) using the same techniques to be used on site.

c. All seaming equipment operators shall have demonstrated performance on previous geomembrane installations and/or documented training.

8. Warranties:

a. General: Should a defect occur, which is covered under warranty, the Warrantor shall bear all costs for repair and/or relocation and replacement of the LLDPE-GM.

b. Workmanship: The Contractor shall furnish the Owner a warranty from the Installer of the LLDPE-GM which warrants their workmanship to be free of defects on a prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to all field seams, anchor trenches, attachments to appurtenances, and penetration seals, as applicable.

c. Manufacturer's Warranty: The Contractor shall furnish the Owner a warranty from the LLDPE-GM Manufacturer for the materials used. The material warranty shall be for defects or failures related to manufacture on a prorata basis for five (5) years after the date of shipment.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes. The LLDPE-GM and LLDPE-GM Manufacturer shall be approved by the Engineer.

The LLDPE-GM shall be supplied in rolls which shall have a minimum width of 22 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest seams. Labels on the roll shall identify the thickness, length, width, lot and roll numbers, and name of Manufacturer.

2. LLDPE-GM Materials:

a. Textured LLDPE-GM shall be 30 mils thick. Resin and sheet properties of LLDPE-GM shall meet or exceed the requirements of GRI GM17 and Table 1 of this section.

b. Materials classified as Very Flexible Polyethylene (VFPE) which otherwise meet the requirements of this section are also acceptable.

3. Extrusion Resin/Typical Extrudate:

Extrusion resin/typical extrudate used for extrusion seaming of LLDPE-GM shall be linear low density polyethylene (LLDPE). Physical properties shall be the same as the LLDPE-GM sheet. The extrudate's additives shall be thoroughly dispersed throughout the rod or bead. The extrudate shall be free of contamination by moisture or foreign matter and shall be recommended for use with the associated sheet material.

4. Texturing:

Textured LLDPE-GM, where required, shall be fabricated using coextrusion or impingement methods. Texturing shall not be created by lamination, structuring, or embossing. Texturing applied to LLDPE-GM using impingement methods shall be bonded securely to the parent LLDPE-GM. All texturing shall be uniform in appearance and coverage on the finished sheet. Textured LLDPE-GM shall be textured on both sides of the sheet.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer:

1. Pre-Installation Requirements:

Prior to LLDPE-GM installation, the Contractor shall submit the following:

a. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the LLDPE-GM attesting that the LLDPE-GM meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of the LLDPE-GM to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

b. Qualifications:

(1) Submit list of equipment and personnel proposed for the Project. Include equipment type and quantities. Include personnel experience on similar projects.

(2) Submit resume and references of Installation Supervisor to be assigned to the Project, including data and duration of employment and pertinent experience information.

(3) Submit resumes and references of installation personnel who will perform seaming operations, including dates and durations of employment and pertinent experience information.

c. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

d. Delivery Date: Submit notification of the scheduled delivery dates for the materials.

e. Installation Procedures and Drawings:

Submit installation procedures and (shop) drawings for carrying out the work.

(1) Installation procedures to be addressed shall include but not be limited to material installation, repair, and protection to be provided in the event of rain or strong winds.

(2) Shop drawings shall have LLDPE-GM sheet layout with proposed size, number, position, and sequence of placing all panels, and indicating the location of all field seams. Shop drawings shall also show complete details and/or methods for anchoring the LLDPE-

GM, making field seams, and making seals around pipes and structures penetrating the LLDPE-GM (if applicable).

Following review, these procedures and drawings shall be used for installation of the LLDPE-GM. Any deviations from these procedures and drawings must be approved by the Engineer and CQA Engineer.

f. Quality Control Certificates: For LLDPE-GM delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of LLDPE-GM. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall meet or exceed the requirements of GRI GM17.

g. Contractor Quality Control Test Results: The Contractor shall provide the results of required testing.

h. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

2. Post-Installation Requirements:

Upon completion of the LLDPE-GM installation, the Contractor shall submit the following:

a. Certificate stating that the LLDPE-GM has been installed in accordance with the Drawings, Specifications, and the Manufacturer's recommendations.

b. Completed Manufacturer's and workmanship warranties.

c. Record Information: Record information shall include but not be limited to:

(1) CQC Documentation: Includes trial seam logs, panel placement logs, panel seaming logs, non-destructive seam testing report forms, field destructive seam testing report forms, and repair logs.

(2) As-Built Drawing: Includes the requirements listed in Paragraph D.8 (Surveying) of this Specification.

Finalization of payment for LLDPE-GM installation shall not be made until the above submittals have been reviewed by the CQA Engineer.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

The LLDPE-GM shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

LLDPE-GM that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and CQA testing of LLDPE-GM supplied as replacement for rejected material shall be performed by the CQA Engineer at Contractor's cost.

3. Subgrade Preparation:

a. The surface of the subgrade shall be smooth, uniform, free from sudden changes in grade (such as vehicular ruts), rocks or stones greater than ½ inch in size, debris, and deleterious materials. During actual placing and seaming of the LLDPE-GM, the subgrade shall be kept free of all standing water. If the subgrade below the LLDPE-GM becomes excessively wet and unstable as determined by the CQA Engineer, it shall be dried and recompacted, and replaced if needed.

b. Before an individual panel of LLDPE-GM is installed; the Contractor and Installer shall verify in writing and submit to the CQA Engineer:

(1) Lines and grades are in conformance with the Drawings and Specifications.

(2) The surface area to be lined has been rolled and compacted, free of irregularities and abrupt changes in grade.

4. LLDPE-GM Placement:

a. Weather Conditions:

LLDPE-GM placement shall not proceed at an ambient temperature below 32° F or above 100° F unless otherwise authorized, in writing, by the Engineer. Installation of LLDPE-GM at temperatures below 32° F, if authorized by the Engineer, shall follow GRI GM9. LLDPE-GM placement shall not be performed during precipitation, excessive moisture, in an area of ponded water, or in excessive winds. Any portion of LLDPE-GM or subgrade damaged due to weather conditions shall be repaired at the Contractor's cost.

b. Method of Placement:

(1) Each panel of the LLDPE-GM shall be installed in accordance with the approved shop drawings prepared by the Contractor. The layout shall be designed to keep field seaming of the LLDPE-GM to a minimum and consistent with proper methods of LLDPE-GM installation.

(2) Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope).

(3) The LLDPE-GM shall be placed smooth and free of excessive wrinkles.

(4) LLDPE-GM rolls shall be placed using proper spreader and rolling bars with cloth slings. If a sheet must be displaced a distance greater than its width, a slip sheet shall be used.

(5) The CQA Engineer shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Engineer and as described in this section.

(6) The Installer shall avoid dragging the LLDPE-GM on rough soil subgrades.

(7) All LLDPE-GM shall be anchored as shown on the Contract Drawings and consistent with Manufacturer's recommendations.

(8) Personnel working on the LLDPE-GM shall not smoke, wear damaging shoes, or involve themselves in any activity that may damage the LLDPE-GM, in the opinion of the CQA Engineer.

(9) The LLDPE-GM shall be properly weighted to avoid uplift due to wind.

(10) Vehicular traffic across the LLDPE-GM shall not be allowed, except that four-wheel (or greater) all-terrain vehicles (ATVs) with low ground pressure may be allowed if approved in advance by the Engineer. The Contractor shall submit proposed equipment and procedures for use of ATVs to the CQA Engineer as part of his submittals. If ATVs are allowed by the Engineer, each ATV shall be operated such that no sudden stops, starts, or turns are made.

(11) All damage shall be recorded and located on the record drawings.

(12) The LLDPE-GM shall be kept free of debris, unnecessary tools, and materials. In general, the LLDPE-GM area shall remain neat in appearance.

c. Pipe Penetrations:

All pipe penetrations through the LLDPE-GM shall be as shown in the Contract Drawings. Alternative penetration details may be approved by the Engineer and CQA Engineer.

5. Field Seams:

a. Individual panels of LLDPE-GM shall be laid out and overlapped by a minimum of 4 inches prior to seaming. The area to be seamed shall be cleaned and prepared in accordance with the Manufacturer's recommendations.

b. Dual or single track hot wedge methods shall be used for straight seams.

c. Extrusion fillet methods shall be used to seam cross seam tees, patches, repairs, and penetration boots. All extrudate shall be free of dirt, dry, and protected from damage. To limit overgrinding, the amount of grinding exposed after an extrusion seam is completed shall be less than ¼ inch.

d. The seaming equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the LLDPE-GM so as to ensure that changes in environmental conditions will not affect the integrity of the seam.

e. All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be seamed together.

f. Where horizontal seams are required on sloped surfaces, the panels shall be placed such that the "upstream" panel forms the upper panel and overlaps the "downstream" panel in order to minimize infiltration potential. All seams constructed on slopes of 6H:1V or steeper shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer. Where approved, end seams on slopes of 6H:1V or steeper shall be staggered a minimum of 5 feet and shall be made at an angle of approximately 45 degrees.

g. All panels placed on slopes of 6H:1V or steeper shall extend a minimum of 5 feet beyond the grade break with a slope flatter than 6H:1V.

h. All seams shall extend to the full extent of the anchor trench (where applicable).

i. Unless otherwise approved by the Engineer, all "T" seams (i.e., the result of three panels placed together) shall be staggered a minimum of 3 feet along either seam and shall be covered with a patch.

j. No junctions of four or more panels shall be allowed unless approved by the Engineer.

k. If extrusion seaming equipment is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extrudate shall be placed on a sacrificial sheet and disposed of.

l. To prevent moisture buildup during seaming, it may be necessary to place a movable protective layer of plastic directly below each overlap of LLDPE-GM that is to be seamed.

m. If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

n. All seams (including repairs) shall meet or exceed the requirements of GRI GM19 and Table 3 of this section.

o. No overlying material shall be placed over the LLDPE-GM until approved by the CQA Engineer.

6. Anchor Trench:

a. The anchor trench shall be constructed as shown on the Contract Drawings and as specified herein. The anchor trench shall be maintained by the Contractor.

b. Slightly rounded corners shall be provided in the trench to avoid sharp bends in the LLDPE-GM.

c. The anchor trench shall be adequately drained to prevent water ponding and softening to adjacent soils. The anchor trench shall be backfilled with controlled fill material and compacted to 90% standard Proctor dry density (ASTM D 698).

d. If the anchor trench is located in a clay susceptible to desiccation, the amount of trench open at any time shall be limited to one day of LLDPE-GM installation capacity.

7. Repair Procedures:

a. Any portion of the LLDPE-GM exhibiting signs of defect or failing a nondestructive or a destructive test, shall be repaired by the Geomembrane Installer. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be made by the CQA Engineer. The procedures available include:

(1) Patching - Apply a new piece of LLDPE-GM sheet over, and at least 6-inches beyond the limits of a defect. The patch shall be extrusion seamed to the underlying LLDPE-GM. This method should be used to repair holes, tears, destructive test locations, undispersed raw materials, contamination by foreign matter, dents, pinholes, and pressure test holes.

(2) Capping - Apply a new strip of LLDPE-GM along the length of a delineated faulty seam. The cap strip shall extend at least 6-inches beyond the limit of the seam and the edges shall be extrusion seamed to the underlying LLDPE-GM. This method should be used to repair lengths of extrusion or hot wedge seams.

(3) Replacement - The faulty seam is removed and replaced.

b. In addition, the following provisions shall be satisfied:

(1) Surfaces of the LLDPE-GM which are to be repaired shall be abraded no more than one hour prior to the repair;

(2) All surfaces must be clean and dry at the time of the repair;

(3) All seaming equipment used in repairing procedures must be approved;

(4) The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA Engineer;

(5) Extrusion seaming of flaps of dual track hot wedge seams is not acceptable. A patch or cap strip shall be used; and

(6) Patches or caps shall extend at least 6-inches beyond the edge of the defect, and all patch corners shall be rounded.

8. Surveying:

a. After completion of a segment of LLDPE-GM, the Contractor shall survey LLDPE-GM to obtain the following information:

(1) Location and numbering of all panels/seams.

(2) Location of all repairs/patches;

(3) Location of all destructive test locations; and

(4) Location of all pipe penetrations and other appurtenances (if applicable).

b. No overlying materials shall be placed before survey information is obtained.

c. The Contractor shall provide the CQA Engineer with updated survey information when requested by the CQA Engineer to verify that the required information is being obtained.

9. Cover Placement:

Placement of materials over LLDPE-GM shall be performed in a manner as to ensure that LLDPE-GM and the underlying geosynthetics are not damaged; minimal slippage of LLDPE-GM on the underlying geosynthetics occurs; no excess tensile stresses occur in the LLDPE-GM; and that no portion of the LLDPE-GM develops excessive wrinkles or crimp. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and covering methods or LLDPE-GM that becomes crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

TABLE 1: REQUIRED LLDPE-GM PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE
Interface Shear Strength (Peak)[1, 2, 3]	ASTM D 5321	psf	55 psf (Load = 200 psf)

Notes:

1. Textured LLDPE-GM shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
2. Note that the required values for textured LLDPE-GM may require an aggressively textured sheet.
3. The specified interface shear strength requirement is based on a finished slope no steeper than 6H:1V. Steeper slopes will require evaluation by the Engineer.

TABLE 2: REQUIRED CONTRACTOR QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Interface Shear Strength	ASTM D 5321	(See Note 1)

Notes:

1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:

   A. Textured LLDPE-GM (30 mil) or GCL against existing cover soils (intermediate cover);
   B. Drainage Geocomposite against textured LLDPE-GM (30 mil) or GCL; and
   C. Vegetative Soil Layer against Drainage Geocomposite.

   If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping.

Upon review of test results, the Engineer may allow exceptions to the above criteria.

For tests involving textured geomembranes, the laboratory shall also report the asperity height (GRI GM12) for the material samples used in the actual direct shear tests.

TABLE 3: REQUIRED SEAM STRENGTH PROPERTIES

PROPERTY	TEST METHOD	VALUE	
		Hot Wedge Seams	**Extrusion Fillet Seams**
30 mil			
Shear Strength[1]	ASTM D 6392	45 lbs/inch	
Shear Elongation at Break[2]		50%	
Peel Strength[1]		38 lbs/inch	34 lbs/inch
Peel Separation (Incursion)		≤ 25%	
Locus-of-Break		See Note 3	

Notes:

1. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.
2. Omit elongation measurements when performing field tests.
3. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392 (in this regard, SIP is an acceptable break code):

   Hot Wedge: AD and AD-BRK with > 25% Separation
   Extrusion Fillet: AD1, AD2, and AD-WLD (unless strength is achieved).

END OF SECTION

SECTION 02930

REVEGETATION

Revegetation: Revegetation includes permanent Revegetation of all site areas disturbed by the Contractor whether inside the Contract Limits or not.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Revegetation in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Vegetative Soil Layer	02258
Erosion and Sedimentation Control	02270
Rolled Erosion Control Products	02275

3. Warranty:

The Contractor shall be responsible for the satisfactory establishment and growth of a permanent stand of vegetation for a period of one year following the final seeding as judged by the Engineer. During this period, the Contractor shall be responsible for the maintenance items described in Paragraph D.4 (Maintenance) of this Specification.

B. MATERIALS

1. Limestone: Unless otherwise defined by specific soil tests, supply agricultural grade ground limestone conforming to the current "Rules, Regulations, and Standards of the Fertilizer Board of Control."

2. Fertilizer: Unless otherwise defined by specific soil tests, supply commercial fertilizer of 10-10-10 analysis, meeting applicable requirements of State and Federal law. Do not use cyanamic compounds of hydrated lime. Deliver fertilizer in original containers labeled with content analysis.

3. Grass Seed: Supply fresh, clean, new-crop seed as specified in Table 1 of this section. Do not use seed which is wet, moldy, or otherwise damaged. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accord with US Department of Agriculture Rules and Regulations under Federal Seed Act.

4. Mulch: Supply clean, seed-free, threshed straw of oats, wheat, barley, rye, beans, or other locally available mulch material.

   a. Do not use mulch containing a quantity of matured, noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.

   b. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of grass.

5. Binder: Supply emulsified asphalt or synthetic binder.

6. Water: Supply potable, free of substances harmful to growth.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Results of soil tests performed and proposed modifications, if any, to the specified requirements.

2. Certificates for each grass seed mixture, stating botanical and common name, percentage by weight, and percentages of purity, germination, and weed seed. Certify that each container of seed delivered is fully labeled in accordance with Federal Seed Act and equals or exceeds specification requirements.

3. Copies of invoices for fertilizer, showing grade furnished and total quantity applied.

D. CONSTRUCTION

1. The Contractor shall establish a smooth, healthy, uniform, close stand of grass from the specified seed. Prior to Revegetation, the Contractor shall adequately test the soils to be revegetated to ensure the adequacy of the specified requirements. Any modifications to these requirements deemed necessary after the review of soil test results, shall be at the Contractor's sole expense. The Engineer will perform the observations to determine when successful Revegetation is achieved.

2. Soil Preparation:

a. Limit preparation to areas which will be planted soon after preparation.

b. Loosen surface to minimum depth of four (4) inches.

c. Remove stones, sticks, roots, rubbish and other extraneous matter over three (3) inches in any dimension.

d. Spread lime uniformly over designated areas at the rate specified in Table 1 of this section.

e. After application of lime, prior to applying fertilizer, loosen areas to be seeded with double disc or other suitable device if soil has become hard or compacted. Correct any surface irregularities in order to prevent pocket or low areas which will allow water to stand.

f. Distribute fertilizer uniformly over areas to be seeded at the rate specified in Table 1 of this section.

(1) Use suitable distributor.

(2) Incorporate fertilizer into soil to depth of a least two (2) inches.

(3) Remove stones or other substances which will interfere with turf development or subsequent mowing.

g. Grade seeded areas to smooth, even surface with loose, uniformly fine texture.

(1) Roll and rake, remove ridges and fill depressions, as required to meet finish grades.

(2) Fine grade just prior to planting.

3. Seeding:

a. Use approved mechanical power driven drills or seeders, mechanical hand seeders, or other approved equipment.

b. Distribute seed evenly over entire area at the rate specified in Table 1 of this section.

c. Stop work when work extends beyond most favorable planting season for species designated, or when satisfactory results cannot be obtained because of drought, high winds, excessive moisture, or other factors.

d. Resume work only when favorable condition develops, or as directed by the Engineer.

e. Lightly rake seed into soil followed by light rolling or cultipacking.

f. Immediately protect seeded areas against erosion by mulching or placing Rolled Erosion Control Products in accordance with Section 02275 of these Specifications, where applicable.

(1) Spread mulch in a continuous blanket at the rate specified in Table 1 of this section.

(2) Immediately following spreading mulch, secure with evenly distributed binder at the rate specified in Table 1 of this section.

4. Maintenance:

The Contractor shall be responsible for maintaining all seeded areas through the end of his warranty period. The Contractor shall provide, at his expense, protection of all seeded areas against damage at all times until acceptance of the work. Maintenance shall include, but not be limited to, the following items:

a. Regrade and revegetate all eroded areas until adequately stabilized by grass.

b. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.

c. Replant bare areas using same materials specified.

TABLE 1: SEEDING SCHEDULE

MATERIAL	SEED TYPE	APPLICATION RATE[1]
Lime	-----	4,000 lbs/acre
Fertilizer	-----	1,000 lbs/acre
Seed Permanent: Temporary:	 Tall Fescue Sericea Lespedeza[2] Kobe Lespedeza Common Bermuda[3] Seasonal Nurse Crop See Note 5	 100 lbs/acre 30 lbs/acre 10 lbs/acre 10 lbs/acre See Note 4 See Note 5
Mulch	-----	4,000 - 5,000 lbs/acre
Binder	-----	150 gallons/acre

Notes:

1. Application rates and/or chemical analysis shall be confirmed or established by a soil test(s).
2. From August 16 - March 1, use unscarified Sericea seed.
3. Use hulled Bermuda seed from April through September and unhulled Bermuda seed from October through March.
4. Use seasonal nurse crop in accordance with seeding dates as stated below:

May 1 - August 15	10 lbs/acre German Millet or 15 lbs/acre Sudangrass
August 16 - April 30	40 lbs/acre Rye (grain).

5. For temporary seeding, follow the guidelines of the NC Erosion and Sediment Control Planning and Design Manual.

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Construction Quality Assurance Manual

Halifax County C&D Landfill
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

June 2008
Revised: January 2010

RICHARDSON SMITH GARDNER & ASSOCIATES
ENGINEERING & GEOLOGICAL SERVICES

14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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HALIFAX COUNTY C&D LANDFILL

CONSTRUCTION QUALITY ASSURANCE MANUAL

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SECTION 1.0
GENERAL

1.1 INTRODUCTION

This Construction Quality Assurance (CQA) Manual has been prepared to provide the Owner, (Design) Engineer, and CQA Engineer the means to govern the construction quality and to satisfy landfill certification requirements under current solid waste management regulations.

More specifically, this CQA Manual addresses the soils and/or geosynthetics components of the landfill subgrade and final cover system. The final cover system on top slopes consists of a LLDPE geomembrane or GCL, overlying granular and geosynthetic drainage material with collection piping, and overlying vegetative soil layer. The final cover system on side slopes consists of a vegetative soil layer.

The CQA Manual is divided into the following sections:

- Section 1.0 General
- Section 2.0 CQA Documentation
- Section 3.0 Earthwork CQA
- Section 4.0 Final Cover System CQA
- Section 5.0 Geomembrane CQA
- Section 6.0 Drainage Geocomposite CQA
- Section 7.0 Geosynthetic Clay Liner CQA

1.2 DEFINITIONS RELATING TO CONSTRUCTION QUALITY

1.2.1 Construction Quality Assurance (CQA)

In the context of this Manual, Construction Quality Assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the final cover system installation with the project drawings and the project specifications. CQA is provided by the CQA Engineer as a representative of the Owner and is independent from the Contractor and all manufacturers. The CQA program is designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

1.2.2 Construction Quality Control (CQC)

Construction Quality Control refers to actions taken by manufacturers, fabricators, installers, and/or the Contractor to ensure that the materials and the workmanship meet the requirements of the project drawings and the project specifications. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Manual by reference only. A complete updated version of each geosynthetic component manufacturer's QC Plan shall be incorporated as part of the Contractor's CQC Plan.

1.2.3 CQA Certification Document

At the completion of construction, a certification document will be prepared by the CQA Engineer and submitted to State Solid Waste Regulators. The certification report will include all QC testing performed by the Geosynthetics Manufacturers, all CQC testing performed by the Geosynthetic Installers, and all CQA testing performed by the CQA Engineer.

1.2.4 Discrepancies Between Documents

The Contractor is instructed to bring discrepancies to the attention of the CQA Engineer who shall then notify the Engineer for resolution. The Engineer has the sole authority to determine resolution of discrepancies existing within the Contract Documents (this may also require the approval of State Solid Waste Regulators). Unless otherwise determined by the Engineer, the more stringent requirement shall be the controlling resolution.

1.3 PARTIES TO CONSTRUCTION QUALITY ASSURANCE

1.3.1 Description of the Parties

The parties to Construction Quality Assurance and Quality Control include the Owner, Engineer, Contractor, Geosynthetics Manufacturer, Geosynthetics Installer, CQA Engineer, Geosynthetics CQA Laboratory, and Soils CQA Laboratory.

1.3.1.1 Owner

The Owner is Halifax County, who owns and/or is responsible for the facility.

1.3.1.2 Engineer

The Engineer is responsible for the engineering design, drawings, and project specifications for the final cover system. The Engineer is an official representative of the Owner. The Engineer serves as communications coordinator for the project, initiating the meetings outlined in **Section 1.7**. The Engineer will also be responsible for proper resolution of all quality issues that arise during construction. The Engineer is Richardson Smith Gardner & Associates, Inc.

1.3.1.3 Contractor

The Contractor is responsible for the construction of the final cover systems. The Contractor is responsible for the overall CQC on the project and coordination of submittals to the CQA Engineer. Additional responsibilities of the Contractor are defined by the project specifications.

1.3.1.4 Geosynthetics Manufacturer

The Geosynthetics Manufacturer(s) is (are) responsible for the production of the geosynthetic components used in landfill construction. The Manufacturer(s) is (are) responsible for Quality Control (QC) during manufacture of the geosynthetic components, certification of the properties of the geosynthetic components, and field installation criteria.

1.3.1.5 Geosynthetics Installer

The Geosynthetics Installer(s) is (are) routinely a subcontractor of the Contractor and is (are) responsible for field handling, storing, placing, seaming, protection of (against wind, etc.), and other aspects of the geosynthetics installations. The Installer may also be responsible for transportation of these materials to the site, and for the preparation and completion of anchor trenches.

1.3.1.6 CQA Engineer

The CQA Engineer is a representative of the Owner, is independent from the Contractor, and is responsible for observing, testing, and documenting activities related to the CQA of the soil and geosynthetic components of the final cover system. The CQA Engineer may make field observations and review submittals for the Engineer and is responsible for notifying the Owner and Engineer of all quality issues that arise during construction. The CQA Engineer is also responsible for issuing a facility certification report, sealed by a Professional Engineer registered in The State of North Carolina.

1.3.1.7 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory is a party, independent from the Owner, that is responsible for conducting tests on conformance samples of geosynthetics used in the final cover system. The Geosynthetics CQA Laboratory service cannot be provided by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components. The services of the Geosynthetics CQA Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.3.1.8 Soils CQA Laboratory

The Soils CQA Laboratory is a party, independent from the Owner, that is responsible for conducting geotechnical tests on conformance samples of soils and aggregates used in structural fills and the final cover system. The services of the Soils CQA Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.3.2 Qualifications of the Parties

The following qualifications are required of all parties involved with the manufacture, fabrication, installation, transportation, and CQA of all materials for the final cover system. Where applicable, these qualifications must be submitted by the Contractor to the Owner and Engineer for review and approval.

1.3.2.1 Contractor

Qualifications of the Contractor are specific to the construction contract and independent of this CQA Manual.

1.3.2.2 Geosynthetics Manufacturers

Each Geosynthetics Manufacturer must satisfy the qualifications presented in the project specifications.

1.3.2.3 Geosynthetic Installer(s)

The Geosynthetic Installer(s) will be trained and qualified to install the geosynthetics components of the final cover system. Each Geosynthetics Installer must meet the requirements of the project specifications and be approved by the Engineer.

1.3.2.4 CQA Engineer

The CQA Engineer will act as the Owner's Quality Assurance Representative. The CQA Engineer will perform CQA testing to satisfy the requirements of this CQA Manual and will prepare the CQA certification document. The CQA Engineer will have experience in the CQA aspects of the construction and testing of landfill final cover systems, and be familiar with ASTM and other related industry standards. The activities of the CQA Engineer will be performed under the supervision of a Registered Professional Engineer.

1.3.2.5 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory should be certified by the Geosynthetics Accreditation Institute, will have experience in testing geosynthetics, and be familiar with ASTM, GRI, and other applicable test standards. The Geosynthetics CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.3.2.6 Soils CQA Laboratory

The Soils CQA Laboratory will have experience in testing structural fill and aggregates, and be familiar with ASTM and other applicable test standards. The Soils CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.4 SCOPE OF CONSTRUCTION QUALITY ASSURANCE MANUAL

The scope of this CQA Manual includes the CQA of the soils and geosynthetic components of the final cover system for the subject facility. The CQA for the selection, evaluation, and placement of the soils is included in the scope.

1.5 UNITS

In this CQA Manual, all properties and dimensions are expressed in U.S. units.

1.6 REFERENCES

The CQA Manual includes references to the most recent version of the test procedures of the American Society of Testing and Materials (ASTM) and/or the Geosynthetic Research Institute (GRI). **Appendix A** contains a list of these procedures.

1.7 CQA MEETINGS

To facilitate the specified degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

1.7.1 Geosynthetics CQA Meeting

A CQA Meeting will be held at the site prior to placement of the geosynthetics. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and the Geosynthetic Installation Superintendent(s).

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and, above all, review the CQA Manual to all of the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all.

This meeting should include all of the activities referenced in the project specifications.

The meeting will be documented by the Engineer and minutes will be transmitted to all parties. The Soil Liner CQA Meeting and the Geosynthetics CQA Meeting may be held as one meeting or separate meetings, depending on the direction of the Engineer.

1.7.2 CQA Progress Meetings

Progress meetings will be held between the Engineer, the CQA Engineer, the Contractor, the Geosynthetic Installation Superintendent(s), and representatives from any other involved parties at the frequency dictated in the project specifications or, at a minimum, once per month during active construction. These meetings will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The CQA Engineer will log any problems, decisions, or questions arising at this meeting in his daily or periodic reports. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties. These meetings will be documented by the Engineer and minutes will be transmitted to affected parties.

1.7.3 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and representatives from any other involved parties. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Engineer and minutes will be transmitted to affected parties.

1.8 CONTROL VERSUS RECORD TESTING

1.8.1 Control Testing

In the context of this CQA Manual, Control Tests are those tests performed on a material prior to its actual use in construction to demonstrate that it can meet the requirements of the project plans and specifications. Control Test data may be used by the Engineer as the basis for approving alternative material sources.

1.8.2 Record Testing

Record Tests are those tests performed during the actual placement of a material to demonstrate that its in-place properties meet or exceed the requirements of the project drawings and specifications.

SECTION 2.0
CQA DOCUMENTATION

2.1 DOCUMENTATION

An effective CQA plan depends largely on recognition of construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Engineer will document that quality assurance requirements have been addressed and satisfied.

The CQA Engineer will provide the Owner and Engineer with his daily and weekly progress reports including signed descriptive remarks, data sheets, and logs to verify that required CQA activities have been carried out. These reports will also identify potential quality assurance problems. The CQA Engineer will also maintain at the job site a complete file of project drawings, reports, project specifications, a CQA Manual, checklists, test procedures, daily logs, and other pertinent documents.

2.2 DAILY CQA REPORT

The CQA Engineer's reporting procedures will include preparation of a daily report which, at a minimum, will include the following information, where applicable:

- a unique identifying sheet number for cross referencing and document control;
- date, project name, location, and other identification;
- data on weather conditions;
- a reduced-scale Site Plan showing all proposed work areas and test locations;
- descriptions and locations of ongoing construction;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- a summary of test results;
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- off-site materials received, including quality verification documentation;

- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality;

- summaries of pertinent discussions with the Contractor and/or Geosynthetic Installers; and

- the CQA Engineer's signature.

The daily report must be completed at the end of each CQA Engineer's shift, prior to leaving the site. This information will be submitted weekly to and reviewed by the Owner and Engineer.

2.3 CQA PROGRESS REPORTS

The CQA Engineer will prepare a summary progress report each week, or at time intervals established at the pre-construction meeting. As a minimum, this report will include the following information, where applicable:

- a unique identifying sheet number for cross-referencing and document control;

- the date, project name, location, and other information;

- a summary of work activities during the progress reporting period;

- a summary of construction situations, deficiencies, and/or defects occurring during the progress reporting period;

- summary of all test results, failures and retests, and

- signature of the CQA Engineer.

The CQA Engineer's progress reports must summarize the major events that occurred during that week. Critical problems that occur shall be communicated verbally to the Engineer immediately as well as being included in the weekly reports. The CQA Engineer's weekly report must be submitted to the Owner and Engineer no later than the Monday following the week reported.

2.4 CQA PHOTOGRAPHIC REPORTING

Photographs will be taken by the CQA Engineer at regular intervals during the construction process and in all areas deemed critical by the CQA Engineer.

These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. These records will be presented to the Engineer upon completion of the project.

In lieu of photographic documentation, videotaping may be used to record work progress,

problems, and mitigation activities. The Engineer may require that a portion of the documentation be recorded by photographic means in conjunction with videotaping.

2.5 DEFICIENCIES

The Owner and Engineer will be made aware of any significant recurring nonconformance with the project specifications. The Engineer will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specification. When this type of evaluation is made, the results will be documented, and any revision to procedures or project specifications will be approved by the Owner and Engineer.

2.6 DESIGN AND/OR PROJECT TECHNICAL SPECIFICATION CHANGES

Design and/or project specification changes may be required during construction. In such cases, the CQA Engineer will notify the Engineer. The Engineer will then notify the appropriate agency, if necessary.

Design and/or project specification changes will be made only with the written agreement of the Engineer, and will take the form of an addendum to the project specifications. All design changes will include a detail (if necessary) and state which detail it replaces in the plans.

2.7 FINAL CQA REPORT

At the completion of each major construction activity at the landfill unit, the CQA Engineer will certify all required forms, observation logs, field and laboratory testing data sheets including sample location plans, etc. The CQA Engineer will also provide a final report which will certify that the work has been performed in compliance with the plans and project technical specifications, and that the supporting documents provide the necessary information.

The CQA Engineer will also provide summaries of all the data listed above with the report. The Record Drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the Record Drawings will be done by the Contractor's Construction Surveyor. These documents will be certified by the Contractor and delivered to the CQA Engineer and included as part of the final CQA (Certification) report.

It may be necessary to prepare interim certifications, as allowed by the regulatory agency to expedite completion and review.

At a minimum, the items shown in **Table 2.1** will be included in the Final CQA Report. Note that some items may not be applicable to all projects.

2.8 STORAGE OF RECORDS

All handwritten data sheet originals, especially those containing signatures, will be stored by the CQA Engineer in a safe repository on site. Other reports may be stored by any standard method which will allow for easy access. All written documents will become property of the Owner.

TABLE 2.1: FINAL CQA REPORT GENERAL OUTLINE

1.0 Introduction
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4.0 Earthwork CQA
5.0 Final Cover System CQA
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SECTION 3.0
EARTHWORK CQA

3.1 INTRODUCTION

This section of the CQA Manual addresses earthwork (excavation and embankment) and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, field control and record tests, and resolution of problems.

3.2 EMBANKMENT MATERIAL APPROVAL

All material to be used as compacted embankment shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

3.2.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries will be made in the daily log.

During stockpiling operations, control tests, as shown on **Table 3.1**, will be performed by the CQA Engineer prior to placement of any compacted embankment.

3.3 SUBGRADE APPROVAL

The CQA Engineer will verify that the compacted embankment subgrade is constructed in accordance with the project specifications.

3.4 EARTHWORK CONSTRUCTION

3.4.1 Construction Monitoring

A. Earthwork shall be performed as described in the project specifications.

B. Only soil previously approved by the CQA Engineer (see **Section 3.2**) shall be used in construction of the compacted embankment. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying,

scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer will monitor protection of the earthwork during and after construction.

3.4.2 Control Tests

The control tests, as shown on **Table 3.2**, will be performed by the CQA Engineer prior to placement of compacted embankment.

3.4.3 Record Tests

The record tests, as shown on **Table 3.2**, will be performed by the CQA Engineer during placement of compacted embankment.

3.4.3.1 Record Test Failure

Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

3.4.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

3.5 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 3.1: CQA TESTING PROGRAM FOR EMBANKMENT MATERIAL APPROVAL

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS:		
Visual Classification	ASTM D 2488	Each Soil
Moisture-Density Relationship	ASTM D 698	5,000 CY per Each Soil

TABLE 3.2: CQA TESTING PROGRAM FOR COMPACTED EMBANKMENT

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS: (See **Table 3.1**)		
RECORD TESTS:		
Lift Thickness	-----	Each Lift
In-Place Density	ASTM D 6938[1]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)
Moisture Content	ASTM D 6938[2]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)
Verification of Subgrade Soil Type (Soil w/in 2 Vertical Feet of Finished Subgrade Elevations)	ASTM D 2488	5,000 ft^2

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.
2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.
3. Conduct subgrade verification using hand augured boring or test pit.

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SECTION 4.0
FINAL COVER SYSTEM CQA

4.1 INTRODUCTION

This section of the CQA Manual addresses the landfill gas (LFG) components, drainage aggregate and piping, and the vegetative soil layer of the final cover system. By reference to **Sections 5.0, 6.0, and 8.0** of this CQA Manual, this section also addresses the geomembrane, drainage geocomposite, and GCL that are included in the final cover system. This section outlines the CQA program to be implemented with regard to material approval, construction monitoring, and resolution of problems.

4.2 FINAL COVER SYSTEM MATERIAL APPROVAL

The CQA Engineer shall verify that the following are provided and installed in accordance with the project drawings, specifications, and this CQA Manual.

4.2.1 Drainage Pipe

A. Receipt of Contractor's submittals on drainage pipe.

B. Review of submittals for drainage pipe for conformity to the project specifications.

4.2.2 LFG System Components

A. Receipt of Contractor's submittals on LFG system components.

B. Review of submittals for LFG system components for conformity to the project specifications.

4.2.3 Aggregates

A. Receipt of Contractor's submittals on aggregates.

B. Review of submittals for aggregates for conformity to the project specifications.

C. Conduct material control tests in accordance with **Table 4.1**.

4.2.4 Geosynthetic Clay Liner

The CQA program for GCL is presented in **Section 7.0** of this CQA Manual.

4.2.5 Geomembrane

The CQA program for geomembranes is presented in **Section 5.0** of this CQA Manual.

4.2.6 Drainage Geocomposite

The CQA program for drainage geocomposite is presented in **Section 6.0** of this CQA Manual.

4.2.9 Vegetative Soil Layer

A. Review the proposed source of vegetative soil layer for conformance with the project specifications.

B. Conduct material control tests in accordance with **Table 4.1**.

4.3 FINAL COVER SYSTEM INSTALLATION

The CQA Engineer will monitor and document the construction of all final cover system components for compliance with the project specifications. Monitoring the construction work for the components of the final cover system includes the following:

- verify location and depth of LFG wells/vents;
- verify location of all piping;
- monitoring the minimum vertical buffer maintained between field equipment and geosynthetics/piping; and
- monitoring that the placement of the final cover system components does not fold or damage the geosynthetics or other underlying layers.

4.4 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 4.1: CQA TESTING PROGRAM FOR FINAL COVER SYSTEM

COMPONENT	PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS:			
Coarse Aggregate:	Gradation	ASTM C 136	5,000 CY
Vegetative Soil Layer:	Visual Classification	ASTM D 2488	Each Load
	Grain Size Analysis	ASTM D 422	5,000 CY
	Atterberg Limits	ASTM D 4318	5,000 CY

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SECTION 5.0
GEOMEMBRANE CQA

5.1 INTRODUCTION

This section of the CQA Manual addresses the geomembrane component of the final cover system and outlines the CQA program to be implemented with regard to manufacturer and installer approval, material approval, subgrade approval, field and laboratory control and record tests, repairs, and resolution of problems.

5.2 GEOMEMBRANE MANUFACTURER AND INSTALLER APPROVAL

The Contractor shall submit the qualifications of the Geomembrane Manufacturer and the Geomembrane Installer, as described in the specifications, to the CQA Engineer for approval.

5.3 GEOMEMBRANE MATERIAL APPROVAL

5.3.1 Geomembrane Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

5.3.2 Shipment And Storage

During shipment and storage, all geomembrane will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

5.3.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls or sheets related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

5.3.4 Material Control Tests

Samples for material control tests, as shown on **Table 5.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the geomembrane. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be 3 feet long by the roll or sheet width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All control test results must be available at the site prior to the deployment of all geomembrane. The CQA Engineer will examine all results from laboratory conformance testing.

5.3.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geomembrane Installer will replace the roll or sheet of geomembrane that is in nonconformance with the project specifications with a roll or sheet that meets project specifications.

B. The Geomembrane Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll or sheet on both sides of the failed roll or sheet. These two samples must both conform to project specifications. If either of these samples fail, then the next numerical roll or sheet will be tested until a passing roll or sheet is found. This additional conformance testing will be at the expense of the Geomembrane Installer. If either of the two closest rolls or sheets fail, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

5.4 GEOMEMBRANE INSTALLATION

5.4.1 Handling

The Geosynthetic Installer will handle all geomembrane in such a manner as required by the project specifications.

5.4.2 Earthwork

5.4.2.1 Surface Preparation

The Geomembrane Installer will certify in writing that the surface on which the geomembrane will be installed meets line and grade, and the surface preparation requirements of the project specifications. The certificate of acceptance will be given to the CQA Engineer prior to commencement of geomembrane installation in the area under consideration. The CQA Engineer will give a copy of this certificate

to the Engineer.

To ensure a timely covering of the subgrade surface, the Engineer may allow subgrade acceptance in areas as small as one acre. After the supporting soil has been accepted by the Geomembrane Installer, it will be the Geomembrane Installer's responsibility to indicate to the Engineer and CQA Engineer any change in the supporting soil condition that may require repair work. If the CQA Engineer concurs with the Geomembrane Installer, then the Engineer will ensure that the supporting soil is repaired.

5.4.2.2 Anchorage System

The CQA Engineer will verify that anchor trenches have been constructed and backfilled according to project specifications and design drawings.

5.4.3 Geomembrane Placement

5.4.3.1 Field Panel Identification

The CQA Engineer will document that the Geomembrane Installer labels each field panel with an "identification code" (number or letter-number consistent with the layout plan) agreed upon by the Geomembrane Installer and CQA Engineer at the Geosynthetics CQA Meeting (see **Section 1.7.2**).

The Geomembrane Installer will establish a table or chart showing correspondence between roll or sheet numbers and field panel identification codes. This documentation shall be submitted to the CQA Engineer weekly for review and verification. The field panel identification code will be used for all quality control and quality assurance records.

5.4.3.2 Field Panel Placement

5.4.3.2.1 Location: The CQA Engineer will verify that field panels are installed at the location indicated in the Geomembrane Installer's layout plan, as approved or modified in **Section 5.4.3.1**.

5.4.3.2.2 Installation Schedule: The CQA Engineer will evaluate every change in the schedule proposed by the Geomembrane Installer and advise the Engineer on the acceptability of that change.

The CQA Engineer will record the identification code, location, and date of installation of each field panel.

5.4.3.2.3 Placement of Geomembrane: The CQA Engineer will verify that project specification related restrictions on placement of geomembrane are fulfilled. Additionally, the CQA Engineer will verify that the supporting soil has not been damaged by weather conditions.

5.4.3.2.4 Damage: The CQA Engineer will visually observe each panel, after placement and prior to seaming, for damage. The CQA Engineer will advise the Engineer which panels, or portion of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Engineer. Repairs will be made according to procedures described in this section.

As a minimum, the CQA Engineer will document that:

- the panel is placed in such a manner that it is unlikely to be damaged; and
- any tears, punctures, holes, thin spots, etc. are either marked by the Geomembrane Installer for repair or the panel is rejected.

5.4.4 Field Seaming

5.4.4.1 Seam Layout

The Geomembrane Installer will provide the CQA Engineer with a seam layout drawing, i.e., a drawing of the area to be lined showing all expected seams. The CQA Engineer and Engineer will review the seam layout drawing and verify that it is consistent with the accepted state of practice and this CQA Manual.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Geosynthetics CQA Meeting (see **Section 1.7.2**). An on-going written record of the seams and repair areas shall be maintained by the Geomembrane Installer with weekly review by the CQA Engineer.

5.4.4.2 Requirements of Personnel

The Geomembrane Installer will provide the CQA Engineer with a list of proposed seaming personnel and their experience records. This document will be reviewed by the CQA Engineer for compliance with project specifications.

5.4.4.3 Seaming Equipment and Products

Field seaming processes must comply with project specifications. Proposed alternate processes will be documented and submitted to the Engineer and CQA Engineer for their approval. Only seaming apparatus which have been specifically approved by make and model will be used. The CQA Engineer will submit all documentation to the Engineer for his concurrence.

5.4.5 Field Seam Control Tests

5.4.5.1 Trial Seams

A. Prior to production seaming, after four (4) hours of continuous seaming, and/or when significant changes in geomembrane or ambient temperature occurs, the Geomembrane Installer shall perform trial seams to verify that seaming conditions and procedures are adequate. Trial seams shall be performed by each operator of extrusion welders and by the primary operator of each wedge welder using seaming equipment to be used in production seaming.

B. Trial seams shall be made on appropriate sized pieces of identical or equivalent geomembrane material.

C. Hot wedge trial seams shall be approximately 72" x 12" with the seam centered lengthwise. Extrusion fillet trial seams shall be approximately 36" x 12" with the seam centered lengthwise. A minimum of four coupons shall be tested in peel and shear (two each) (ASTM D 6392) by the Geomembrane Installer using a field tensiometer. All coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. Each trial seam shall be assigned a number and the test results recorded in the appropriate log by the Geomembrane Installer. The CQA Engineer will observe all trial seams and compile all trial seam logs.

5.4.6 Field Seam Record Tests

5.4.6.1 Nondestructive Seam Continuity Testing

The Geomembrane Installer shall test and document all seams continuously over their full length using one of the following nondestructive seam tests. This testing shall be performed simultaneously with geomembrane deployment as the work progresses and not at the completion of all field seaming.

A. Vacuum Testing shall conform to ASTM D 5641 requirements.

B. Air Pressure Testing (for double seam with an enclosed space) shall conform to ASTM D 5820 requirements and the requirements listed in **Table 5.2**.

The CQA Engineer will observe the nondestructive testing on a full time basis to ensure conformance with this CQA Manual and the project specifications.

5.4.6.2 Field Destructive Seam Testing

A. The Geomembrane Installer shall obtain 12" x 30" (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at an average frequency of one sample per 500 linear feet of seam. The sample shall be cut into two equal-length pieces, one for field destructive seam testing by the Geosynthetics Installer and one given to the CQA Engineer as an archive sample. The date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. The Geomembrane Installer shall perform and document field destructive seam testing using a field tensiometer which has been calibrated within the prior 6 months (calibration information shall be provided to the CQA Engineer). A minimum of three (3) coupons each will be tested in peel and shear (ASTM D 6392). Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

C. The CQA Engineer or the Owner may require additional random samples to be taken for testing in areas which visually appear defective and not in accordance with the project requirements.

D. All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in this manual.

5.4.6.3 Geosynthetics CQA Laboratory Destructive Testing

A. The Geomembrane Installer shall obtain 12" x 30" (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at an average frequency of one sample per day to confirm field destructive seam tests. The sample shall be cut into two equal-length pieces, both to be given to the CQA Engineer for laboratory destructive seam testing and as an archive sample. The date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. Laboratory destructive test samples will be packaged and shipped to the

Geosynthetics CQA Laboratory by the CQA Engineer in a manner that will not damage the test sample.

C. A minimum of five (5) coupons each will be tested in peel and shear (ASTM D 6392) by the Geosynthetics CQA Laboratory. Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. All geomembrane destructive test samples that fail to meet project specifications will be saved and sent to the CQA Engineer for observation.

E. The CQA Engineer will review laboratory test results as soon as they become available.

5.4.6.4 Field Seam Record Test Failure

For noncomplying tests, the CQA Engineer will:

- observe continuity testing of the repaired areas performed by the Geomembrane Installer;
- confirm the record location, date, test unit number, name of tester, and compile the record of testing provided by the Geomembrane Installer;
- provide a walk-through inspection of all impacted seam areas and verify that the areas have been tested in accordance with the CQA Manual and project specifications; and
- verify that the Geomembrane Installer has marked repair areas with the appropriate color-coded marking pencil.

5.4.6.5 Defining Extent of Field Seam Record Test Failure

All defective seam test failures must be bounded by acceptable destructive tests. The CQA Engineer will document repair actions taken in conjunction with all seam test failures.

5.4.7 Repairs & Verification

5.4.7.1 Repair Procedures

A. All repair procedures shall be in accordance with the project specifications. The CQA Engineer will observe all repair procedures.

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

C. After an extrusion seam is made, no more than ¼ inch of abrasion shall be visible beyond the weld.

5.4.7.2 Repair Verification

A. Each repair shall be numbered and logged by the Geomembrane Installer.

B. Each repair shall be non-destructively tested by the Geomembrane Installer using the methods described above. Repairs which pass non-destructive testing shall be taken as an indication of an adequate repair.

C. Repairs more than 150 feet long may be of sufficient length to require destructive test sampling, at the discretion of the CQA Engineer. A failed test indicates that the repair shall be redone and retested until passing test results are achieved.

5.5 LINER SYSTEM ACCEPTANCE

The geomembrane component of the liner system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- CQA Engineer provides the Engineer with a final copy of the nondestructive test documentation, repair information, and as-built drawings, as submitted by the Geomembrane Installer;
- CQA Engineer provides the Engineer with a certification, submitted by the Geomembrane Installer that the geomembrane was installed in accordance with the Geomembrane Manufacturer's recommendations as well as the project drawings and project specifications; and
- all documentation of the installation is completed including the CQA Engineer's final report.

5.6 MATERIALS IN CONTACT WITH GEOMEMBRANES

The quality assurance procedures indicated in this subsection are only intended to assure that the installation of these materials does not damage the geomembrane. All reasonable measures to protect the geomembrane and provide additional quality assurance procedures are necessary to assure that systems built with these materials will be constructed to ensure proper performance.

5.6.1 Soils

Prior to placement, the CQA Engineer will visually confirm that all soil materials to be placed against the geomembrane comply with project specifications. The Geomembrane Installer will provide the CQA Engineer a written surface acceptance certificate in accordance with **Section 5.4.2**. All soil materials shall be placed and compacted in accordance with project specifications.

5.6.2 Sumps and Appurtenances

The CQA Engineer will verify that:

- installation of the geomembrane in appurtenance areas, and connection of the geomembrane to appurtenances have been made according to the project specifications;
- extreme care is taken while seaming around appurtenances since neither nondestructive nor destructive testing may be feasible in these areas; and
- the geomembrane or appurtenances have not been visibly damaged while making connections to appurtenances.

5.7 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 5.1: CQA TESTING PROGRAM FOR GEOMEMBRANE MATERIAL APPROVAL

PROPERTY	TEST METHOD	TEST FREQUENCY
Thickness	ASTM D 5199/D 5994	100,000 ft^2 or 1 per Lot[1]
Density	ASTM D 1505/D 792	100,000 ft^2 or 1 per Lot[1]
Carbon Black Content	ASTM D 1603	100,000 ft^2 or 1 per Lot[1]
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 or 1 per Lot[1]
Tensile Properties:	ASTM D 6693 (Type IV)	
Tensile Strength at Yield		100,000 ft^2 or 1 per Lot[1]
Tensile Strength at Break		100,000 ft^2 or 1 per Lot[1]
Elongation at Yield		100,000 ft^2 or 1 per Lot[1]
Elongation at Break		100,000 ft^2 or 1 per Lot[1]
Tear Resistance	ASTM D 1004	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

TABLE 5.2 AIR PRESSURE TEST REQUIREMENTS

MATERIAL	MIN. PRESSURE (PSI)	MAX. PRESSURE DROP (PSI) AFTER 5 MINUTES
30 Mil LLDPE	15	3

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SECTION 6.0
DRAINAGE GEOCOMPOSITE CQA

6.1 INTRODUCTION

This section of the CQA Manual addresses drainage geocomposite (DGC) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

6.2 DGC MATERIAL APPROVAL

6.2.1 DGC Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

6.2.2 Shipment And Storage

During shipment and storage, all DGC will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

6.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

6.2.4 DGC Material Control Tests

Samples for material control tests, as shown on **Table 6.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the DGC. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be 3 feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all DGC. The CQA

Engineer will examine all results from laboratory testing.

6.2.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of DGC that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fail, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fail, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

6.3 DGC INSTALLATION

6.3.1 Handling And Placement

The Geosynthetic Installer will handle and place all DGC in such a manner as required by the project specifications.

6.3.2 Stacking And Joining

When several layers of DGC are stacked, care should be taken to ensure that stacked DGC are placed in the same direction. Stacked DGC will never be laid in perpendicular directions to the underlying DGC (unless otherwise specified by the Engineer). The CQA Engineer will observe the stacking of DGC.

Adjacent rolls of DGC will be joined according to construction drawings and project specifications.

6.3.3 Repairs

Any holes or tears in the DGC will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

6.3.4 Placement Of Overlying Materials

All soil materials located on top of DGC shall be placed in accordance with the project specifications.

6.4 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 6.1: CQA TESTING PROGRAM FOR DGC MATERIAL APPROVAL

PROPERTY	TEST METHOD	TEST FREQUENCY
CONTROL TESTS:		
Thickness (geonet only)	ASTM D 5199	100,000 ft^2 or 1 per Lot[1]
Density (geonet only)	ASTM D 1505	100,000 ft^2 or 1 per Lot[1]
Ply Adhesion	ASTM D 413/ GRI GC7	100,000 ft^2 or 1 per Lot[1]
Transmissivity	ASTM D 4716[2]	1 per Resin Lot

Notes:

1. Whichever provides the larger number of tests.
2. Conduct tests for transmissivity in accordance with the conditions given in the project specifications.

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SECTION 7.0
GEOSYNTHETIC CLAY LINER (GCL) CQA

7.1 INTRODUCTION

This section of the CQA Manual addresses geosynthetic clay liner (GCL) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

7.2 GCL MANUFACTURER AND INSTALLER APPROVAL

The Contractor shall submit the qualifications of the GCL Manufacturer and the GCL Installer, as described in the specifications, to the CQA Engineer for approval.

7.3 GCL MATERIAL APPROVAL

7.3.1 GCL Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

7.3.2 Shipment And Storage

During shipment and storage, GCL will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

7.3.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and
- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

7.3.4 GCL Material Control Tests

Samples for material control tests, as shown on **Table 7.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the GCL. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be 3 feet long by the roll width. The CQA

Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all GCL. The CQA Engineer will examine all results from laboratory testing.

7.3.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of GCL that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fail, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fail, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

7.4 GCL INSTALLATION

7.4.1 Handling And Placement

The Geosynthetic Installer will handle and place all GCL in such a manner as required by the project specifications.

7.4.2 Seams And Overlaps

All GCL will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

7.4.3 Repairs

Any holes or tears in the GCL will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

7.4.4 Placement Of Overlying Materials

All soil materials located on top of the GCL shall be placed in accordance with the project specifications.

7.5 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 7.1: CQA TESTING PROGRAM FOR GCL MATERIAL APPROVAL

PROPERTY	TEST METHOD	TEST FREQUENCY
CONTROL TESTS:		
Hydraulic Conductivity	ASTM D 5084/D 5887	100,000 ft^2 or 1 per Lot[1]
Bentonite Content	ASTM D 5993 (@ 0% moisture)	100,000 ft^2 or 1 per Lot[1]
Peel Strength	ASTM D 6496	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

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Appendix A

Reference List of Test Methods

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APPENDIX A: REFERENCE LIST OF TEST METHODS

American Society American Society of Testing and Materials (ASTM):

ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 413	Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate.
ASTM D 422	Standard Test Method for Particle Size Analysis of Soils.
ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head).
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.

ASTM D 3042	Standard Test Method for Insoluble Residue in Carbonate Aggregates.
ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5641	Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
ASTM D 5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.

ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

Geosynthetic Research Institute (GRI):

GRI GC7	Determination of Adhesion and Bond Strength of Geocomposites.

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Operations Manual

Halifax County Landfill Facility
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

June 2008
Revised: January 2010

RICHARDSON SMITH GARDNER & ASSOCIATES
ENGINEERING & GEOLOGICAL SERVICES

14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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HALIFAX COUNTY LANDFILL FACILITY

OPERATIONS MANUAL

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SECTION 1.0
GENERAL FACILITY OPERATIONS

1.1 OVERVIEW

This Operations Manual was prepared for operations of the Halifax County Landfill facility (Permit No. 42-04) located near Littleton. This document discusses the operation of the following landfill units and other solid waste management activities:

- Area 1 C&D Landfill Unit (vertical expansion over closed unlined MSW unit);
- Area 2 C&D Landfill Unit (Proposed);
- Ash Monofill;
- Animal Waste Disposal Area;
- Wood Waste Processing Area;
- White Goods Handling Area;
- Used Tire Storage Area; and
- Used Pesticide Container Storage Area.

Refer to **Figure 1** for the location of existing and proposed landfill units and other solid waste management activities.

The information contained herein was prepared to provide landfill personnel with a clear understanding of how the Design Engineer assumed that the completed facility would be operated. While deviations from the operations outlined here may be acceptable, they should be reviewed and approved by the Design Engineer. Please refer to the appropriate permit application for a detailed discussion and calculations for the individual components of each landfill unit, including phasing plans.

1.2 CONTACT INFORMATION

All correspondence and questions concerning the operation of the Halifax County Landfill should be directed to the appropriate County and State personnel listed below. For fire or police emergencies dial 911.

1.2.1 Halifax County

Halifax County Department of Public Utilities
26 N. King Street (Public Works Bldg.)
P.O. Box 70
Halifax, NC 27839
Phone: (252) 583-1451
Fax: (252) 593-5014
Contact: Gwen Matthews, Interim Director

Halifax County Landfill
921 Liles Road
Littleton, NC 27850
Phone: (252) 586-7516
Fax: (252) 586-2685
Contact: Larry Garriss, Solid Waste Director

1.2.2 North Carolina Department of Environment and Natural Resources

North Carolina DENR - Raleigh Central Office (RCO)
401 Oberlin Road
Raleigh, NC 27605
Phone: (919) 508-8400
Fax: (919) 715-3605

North Carolina DENR - Wilmington Regional Office (WRO)
127 Cardinal Drive Extension
Wilmington, NC 28405
Phone: (910) 796-7215
Fax: (910) 350-2004

North Carolina DENR - Raleigh Regional Office (RRO)
3800 Barrett Drive
Raleigh, NC 27609
Phone: (919) 571-4700
Fax: (919) 571-4718

Division of Waste Management (DWM) - Solid Waste Section:

Field Operations Branch Head:	Mark Poindexter (RCO)
Eastern Regional Supervisor:	John Crowder (WRO)
Waste Management Specialist:	Mary Whaley (RCO)

Division of Land Resources - Land Quality Section:

Regional Engineer:	John Holley, P.E. (RRO)

1.3 ACCESS CONTROL

Limiting access to the landfill facility is important for the following reasons:

- Unauthorized and illegal dumping of waste materials is prevented.
- Trespassing, and injury resulting therefrom, is discouraged.
- The risk of vandalism is greatly reduced.

Access to active areas of the landfill will be controlled by a combination of fences and natural barriers, and strictly enforced operating hours. A landfill attendant will be on duty at all times when the facility is open for public use to enforce access restrictions (see also **Section 1.9**).

1.3.1 Physical Restraints

The site will be accessed by the existing entrance on Liles Road. Scales and a scale house and office are provided at the entrance. All waste will have been weighed prior to being placed in the landfill. The entrance has a gate which will be securely locked during non-operating hours.

1.3.2 Security

Frequent inspections of gates and fences will be performed by landfill personnel. The County will arrange for a random security patrol of the main gate to further discourage trespassing. Evidence of trespassing, vandalism, or illegal operation will be reported to the County Solid Waste Director.

1.4 SIGNAGE

A prominent sign(s) containing the information required by the DWM will be placed at the landfill entrance. This sign(s) will provide information on operating hours, operating procedures, and acceptable wastes. Additional signage will be provided as necessary within the landfill complex to distinctly distinguish the roadway to the active landfill unit(s). Service and maintenance roads for use by operations personnel will be clearly marked and barriers (e.g., traffic cones, barrels, etc.) will be provided as required.

1.5 COMMUNICATIONS

Two way radio communication will be maintained between the active landfill unit(s) and the landfill scale house and office. The scale house and office have telephones in case of emergency and for the conduct of day-to-day business. Emergency telephone numbers are displayed in the scale house and office.

1.6 FIRE AND SAFETY

1.6.1 Fire Control

Although no open burning of waste is allowed at the facility, the possibility of fire within the landfill or a piece of equipment must be anticipated in the daily operation of the landfill. A combination of factory installed fire suppression systems and/or portable fire extinguishers will be operational on all heavy pieces of equipment at all times. For larger or more serious outbreaks, the local fire department will respond.

Fires within the landfill will be limited by the use of daily and intermediate cover as a fire

break and control of "hot" loads entering the landfill. Landfill personnel at the scale house will turn away all trucks containing waste that is suspected to be hot. If a hot load is placed on the working face, then the load will be spread as thin as possible and daily cover soil will be immediately placed on the waste to extinguish the fire.

In general, fires that break out close to the surface of the disposal area should be excavated and smothered with cover material. Deep fires should be smothered out by placing moist soil on the surface and by constructing soil barriers around the fire. Where the smothering technique fails, the burning material must be excavated and smothered or quenched with water once the burning material is brought to the surface. Water is usually not effective unless it can be directly applied to the burning material.

The County will verbally notify the DWM (see **Section 1.2.2**) within 24 hours of discovery of a fire within any landfill disposal area. In addition, written documentation describing the fire, the actions carried out to extinguish the fire, and a strategy for preventing future occurrences will be provided to the DWM within 15 days following any such occurrence.

1.6.2 Safety

All aspects of the operation of the landfill facility were developed with the health and safety of the landfill's operating staff, customers, and neighbors in mind. Prior to commencement of operations in the new landfill phase/area, a member of the landfill operating staff will be designated site safety officer. This individual, together with the facility's management will modify the site safety and emergency response program to remain consistent with National Solid Waste Management Association and Occupational Safety and Health Administration (OSHA) guidance.

Safety equipment provided includes equipment rollover protective cabs, seat belts, audible reverse warning devices, hard hats, safety shoes, and first aid kits. Landfill personnel will be encouraged to complete the American Red Cross Basic First Aid Course. Other safety requirements as designated by the County will also be implemented.

1.7 SEVERE WEATHER CONDITIONS

Unusual weather conditions can directly affect the operation of the landfill facility. Some of these weather conditions and recommended operational responses are as follows.

1.7.1 Ice Storms

An ice storm can make access to the landfill dangerous, prevent movement or placement of daily cover, and, thus, may require closure of the landfill until the ice is removed or has melted.

1.7.2 Heavy Rains

Exposed soil surfaces can create a muddy situation in some portions of the landfill during rainy periods. The control of drainage and use of crushed stone on unpaved roads should provide all-weather access for the site and promote drainage away from critical areas. In areas where the aggregate surface is washed away or otherwise damaged, new aggregate should be used for repair.

Intense rains can affect newly constructed drainage structures such as swales, diversions, cover soils, and vegetation. After such a rain event, inspection by landfill personnel will be initiated and corrective measures taken to repair any damage found before the next rainfall.

1.7.3 Electrical Storms

The open area of a landfill is susceptible to the hazards of an electrical storm. If necessary, landfilling activities will be temporarily suspended during such an event. To guarantee the safety of all field personnel, refuge will be taken in the on-site buildings or in rubber-tired vehicles.

1.7.4 Windy Conditions

Landfill operations during a particularly windy period may require that the working face be temporarily shifted to a more sheltered area. Periodic cover will be placed as required.

1.7.5 Violent Storms

In the event of hurricane, tornado, or severe winter storm warning issued by the National Weather Service, landfill operations may be temporarily suspended until the warning is lifted. Daily cover will be placed on exposed waste and buildings and equipment will be properly secured.

1.8 EQUIPMENT REQUIREMENTS

The County will maintain on-site equipment required to perform the necessary landfill activities. Periodic maintenance of all landfilling equipment, and minor and major repair work will be performed at designated maintenance zones outside of the landfill.

1.9 PERSONNEL REQUIREMENTS

At least one member of the landfill supervisory staff will be certified as a Manager of Landfill Operations (MOLO) by the Solid Waste Association of North America (SWANA). Each landfill employee will go through an annual training course (led by supervisory staff) and is certified by SWANA as Landfill Operations personnel. As part of this training, personnel learn to recognize loads which may contain prohibited wastes.

At least one trained individual will be on duty at the site while the facility is open for public use and at all times during active waste management operations to ensure compliance with operational requirements.

1.10 UTILITIES

Electrical power, water, telephone, and restrooms will be provided at the landfill scale house and/or office.

1.11 RECORD KEEPING PROGRAM

The County will maintain the following records in an operating record at the landfill:

A. Current permit(s);
B. Inspection reports;
C. Audit and compliance records;
D. Annual landfill reports;
E. Waste inspection records (see **Section 2.4**);
F. Daily tonnage records - including source of generation;
G. Waste determination records;
H. Quantity, location of disposal, generator, and special handling procedures for all special wastes disposed of at the site;
I. List of generators and haulers that have attempted to dispose of restricted wastes;
J. Employee training procedures and records of training completed;
K. All ground water monitoring and surface water quality information (See the current **Water Quality Monitoring Plan**) including:
    1. Monitoring well construction records;
    2. Sampling dates and results;
    3. Statistical analyses; and
    4. Results of inspections, repairs, etc.
L. Gas monitoring results and remediation measures as required (see **Section 3.4.2**);
M. All closure and post-closure information, where applicable, including:
    1. Notification of intent to close;
    2. Testing;
    3. Certification; and
    4. Recording.
N. Cost estimates or financial assurance documentation.
O. A notation of the date and time of cover placement.

The operating record will be kept up to date by the Solid Waste Director or his designee. It will be presented upon request to the DWM for inspection. A copy of this Operations Manual will be kept at the landfill and will be available for use at all times.

SECTION 2.0
WASTE HANDLING OPERATIONS

2.1 OVERVIEW

This section describes the required waste handling operations for the Halifax County Landfill facility. In addition to the C&D and ash waste disposed of at this facility, the County also handles white goods, used tires, and used pesticide containers. These materials are stored at the landfill facility until there are sufficient quantities for pick up by various recycling contractors. The County also operates an animal waste disposal area and a wood waste processing area.

2.2 ACCEPTABLE WASTES

2.2.1 C&D Landfill Units

Only the following wastes generated within the approved service area may be disposed of in the C&D landfill unit (Note list is in accordance with existing permit):

- Land Clearing and Inert Debris Landfill: as defined in 15A NCAC 13B.0101(54) means a facility for the disposal of land-clearing waste, concrete, brick, concrete block, uncontaminated soil, gravel and rock, untreated and unpainted wood, and yard trash.
- Land Clearing Waste: as defined in 15A NCAC 13B.0101(53) means solid waste which is generated solely from land-clearing activities, limited to stumps, trees, limbs, brush, grass, and other naturally occurring vegetative material.
- Asphalt: in accordance with NCGS 130A-294(m).
- Construction and Demolition Debris: as defined in NCGS 130A-290(a)(4) means solid waste resulting solely from construction, remodeling, repair, or demolition operations on pavement, buildings, or other structures, but does not include inert debris, land-clearing debris, or yard debris.
- Industrial solid waste that is generated by mobile or modular home manufacturers and asphalt shingle manufacturers in Halifax County. The waste must be separated at the manufacturing site to exclude municipal solid waste, hazardous waste, and other waste prohibited from disposal in a Construction and Demolition Landfill.
- Other Wastes as Approved by the Solid Waste Section of the Division of Waste Management.

In addition, the special wastes (asbestos only) described in **Section 2.5.4** may also be disposed of in the C&D landfill units.

2.2.2 Ash Monofill

Only coal combustion by-products (residuals including fly ash, bottom ash, boiler slag, and flue gas desulfurization residue produced by coal fired electrical or steam generation

units) generated within the approved service area may be disposed of in the ash monofill.

2.2.3 Wood Waste Processing Area

Clean wood waste including pallets, lumber scraps, and yard waste is accepted for processing within the facility's wood waste processing area (see **Section 2.6**).

2.3 PROHIBITED WASTES

2.3.1 C&D Landfill Units

Only wastes, as defined in **Section 2.2.1** above may be accepted for disposal in the C&D landfill unit. No other wastes may be accepted.

2.3.2 Ash Monofill

Only wastes, as defined in **Section 2.2.2** above may be accepted for disposal in the ash monofill. No other wastes may be accepted.

2.3.3 Wood Waste Processing Area

Only clean wood waste as defined in **Section 2.2.3** above may be accepted. No other wastes may be accepted. Unacceptable wastes found in this area, if not otherwise prohibited, are disposed of within the active C&D landfill unit.

2.4 WASTE SCREENING PROGRAMS

In order to assure that prohibited wastes are not entering the landfill facility, screening programs have been implemented at the landfill. Waste received at both the scale house entrance and waste taken to the working face is inspected by trained personnel. These individuals have been trained to spot indications of suspicious wastes, including: hazardous placarding or markings, liquids, powders or dusts, sludges, bright or unusual colors, drums or commercial size containers, and "chemical" odors. Screening programs for visual and olfactory characteristics of prohibited wastes are an ongoing part of the landfill operation.

2.4.1 Waste Receiving and Inspection

All vehicles must stop at the scale house located at the entrance of the facility and visitors are required to sign-in. All waste transportation vehicles are weighed and the content of the load assessed. The scale attendant(s) requests from the driver of the vehicle a description of the waste it is carrying to ensure that unacceptable waste is not allowed into the landfill. The attendant(s) then visually checks the vehicle as it crosses the scale. Signs informing users of the acceptable and unacceptable types of waste are posted at the scale house. Once passing the scales, the vehicles are routed to the appropriate landfill unit or other area (white goods handling area, etc.) as appropriate.

Vehicles are randomly selected for screening on a regular basis a minimum of three times per quarter (i.e. three months). However, if something looks suspicious is spotted in any waste load, that load is inspected further.

Vehicles selected for inspection are directed to an area of intermediate cover adjacent to the working face where the vehicle will be unloaded. Waste is carefully spread using suitable equipment. An attendant trained to identify wastes that are unacceptable at the landfill inspects the waste discharged at the screening site. If unacceptable waste is found, including wastes generated from outside of the service area, the load will be isolated and secured by berming off the area. For unacceptable wastes that are non-hazardous, the Solid Waste Director will then notify officials of the DWM (see **Section 1.2.2**) within 24 hours of attempted disposal of any waste the landfill is not permitted to receive in order to determine the proper course of action. For unacceptable wastes that are hazardous, the Hazardous Waste Contingency Plan outlined in **Section 2.4.2** will be followed. The hauler is responsible for removing unacceptable waste from the landfill property.

If no unacceptable waste is found, the load will be pushed to the working face and incorporated into the daily waste cell. All random waste inspections will be documented by landfill staff using the waste screening form provided in **Appendix A**.

In addition to random waste screening described above, waste unloaded on the active face will be inspected by the equipment operators, trained to spot unacceptable wastes, before and during spreading and compaction. Any suspicious looking waste is reported immediately to the designated primary inspector for further evaluation.

2.4.2 Hazardous Waste Contingency Plan

In the event that identifiable hazardous waste or waste of questionable character is detected at the landfill, appropriate equipment, protective gear, personnel, and materials as necessary will be employed to isolate the wastes. The DWM will be notified immediately (see **Section 1.2.2**) that an attempt was made to dispose of hazardous waste at the landfill. If the vehicle attempting disposal of such waste is known, all attempts will be made to prevent that vehicle from leaving the site or, if the vehicle has left the site, immediate notice will be served on the owner of the vehicle that hazardous waste, for which they have responsibility, has been disposed of at the landfill.

The County will assist the DWM as necessary and appropriate in the removal and disposition of the hazardous waste and in the prosecution of responsible parties. If needed, the hazardous waste will be covered with either on-site soils or other tarping material until such time when an appropriate method can be implemented to properly handle the waste. The cost of the removal and disposing of the hazardous waste will be charged to the owner of the vehicle involved. Any vehicle owner or operator who knowingly dumps hazardous waste in the landfill may be barred from using the landfill.

Should an incident where hazardous waste is found at the landfill occur, the event will be documented by landfill staff using the waste screening form provided in **Appendix A**.

Records of information gathered as part of the waste screening programs will be maintained at the landfill site during its active life and as long as required by the County and the DWM.

2.5 WASTE DISPOSAL

2.5.1 Access

Traffic will be clearly directed to the appropriate active access road. The location of access roads during waste placement will be determined by operations personnel in order to reflect waste placement strategy. Additionally, access will be maintained for site monitoring locations.

2.5.2 General Procedures

For each active landfill unit, waste transportation vehicles will arrive at the working face at random intervals. There may be a number of vehicles unloading waste at the same time, while other vehicles are waiting. In order to maintain control over the unloading of waste, a certain number of vehicles will be allowed on the working face at a time. The actual number will be determined by the truck spotter. This procedure will be used in order to minimize the potential of unloading unacceptable waste and to control disposal activity. Operations at the working face will be conducted in a manner which will encourage the efficient movement of transportation vehicles to and from the working face, and to expedite the unloading of waste.

The approach to the working face will be maintained such that two or more vehicles may safely unload side by side. A vehicle turn-around area large enough to enable vehicles to arrive and turn around safely with reasonable speed will be provided adjacent to the unloading area. The vehicles will back to a vacant area near the working face to unload. Upon completion of the unloading operation, the transportation vehicles will immediately leave the working face area. Personnel will direct traffic necessary to expedite safe movement of vehicles.

Waste unloading at the landfill will be controlled to prevent disposal in locations other than those specified by site management. Such control will also be used to confine the working face to a minimum width, yet allow safe and efficient operations. The width and length of the working face will be maintained as small as practical in order to maintain the appearance of the site, control windblown waste, and minimize the amount of cover required each day. Normally, only one working face will be active on any given day, with all deposited waste in other areas covered by either periodic, intermediate, or final cover, as appropriate.

The procedures for placement and compaction of C&D waste include: unloading of vehicles, spreading of waste into 2 foot lifts, and compaction on relatively flat slopes (i.e. 5H:1V max.) using a landfill compactor and a minimum number of three full passes. For the ash monofill, the ash is spread and tracked in with a bulldozer.

The use of portable signs with directional arrows and portable traffic barricades will facilitate the unloading of wastes to the designated disposal locations. These signs and barricades will be placed along the access route to the working face of the landfill or other designated areas which may be established.

2.5.3 Ash Monofill

The following are items unique to the ash monofill in that this unit includes a geomembrane liner.

2.5.3.1 Placement of Initial Lift

During ash placement, the geomembrane liner is most vulnerable during the placement of the first lift of ash. The first lift should be a minimum of two (2) to four (4) feet thick and be carefully spread using a bulldozer. A spotter should be used during placement of the first lift of ash to ensure that no stretching or wrinkling of the geomembrane is occurring.

In the event that the landfill staff identifies any damage to any part of the geomembrane liner, they should immediately initiate its repair. Additionally, they should document the damage and the repair as a part of the operating record.

2.5.3.2 Equipment Operations Within the Landfill

Both the facility's operational vehicles and waste transportation vehicles must be restricted as follows within the ash monofill:

- Equipment operation directly on the protective cover will be limited to rubber-tired vehicles having a maximum ground contact, i.e., tire pressure, of less than 32 psi.
- A minimum vertical separation of 3 feet will be maintained between the geomembrane liner and all ash transportation vehicles.
- A minimum vertical separation of 2 feet will be maintained between the geomembrane liner and bulldozers used in placement of the ash.

The operation of vehicles within those portions of the ash monofill not actively receiving waste should be restricted to activities associated with erosion and sedimentation control.

2.5.4 Special Waste Management

2.5.4.1 Asbestos Management (C&D Landfill Units)

The County may dispose of asbestos within the C&D landfill units. Asbestos will only be accepted if it has been processed and packaged in accordance with State and Federal (40 CFR 61) regulations. Asbestos will arrive at the site in vehicles that contain only the asbestos waste and only after advance notification by the generator.

Once the hauler brings the asbestos to the landfill, the hauler will be directed to the designated asbestos disposal area by operations personnel. The designated disposal area will be prepared by operations personnel by leveling a small area using a dozer or loader. Prior to disposal, the landfill operators will stockpile cover soil near the designated asbestos disposal area. The volume of soil stockpiled will be sufficient to cover the waste and to provide any berms, etc. to maintain temporary separation from other landfill traffic.

Once placed in the prepared area, the asbestos waste will be covered with a minimum of 18 inches of cover soil placed in a single lift. The surface of the cover soil will be compacted and graded using a tracked dozer or loader. The landfill compactor will be prohibited from operating over asbestos disposal areas until at least 18 inches of cover are in-place.

The landfill staff will record the approximate location and elevation of the asbestos waste once cover is in-place. The Solid Waste Director will then review pertinent disposal and location information to assure compliance with regulatory requirements and enter the information into the Operating Record.

Once disposal and recording for asbestos waste is completed, the disposal area may be covered with waste. No excavation into designated asbestos disposal areas will be permitted.

2.5.4.2 Animal Carcasses (Animal Waste Disposal Area)

The disposal of animal carcasses within the animal waste disposal area will be handled as follows. The generator of the carcass(es) must call in advance to the landfill, and a determination will be made as to whether or not the carcass(es) will be accepted. If approved, the generator will deliver the carcass(es) at a predetermined time. An area for disposal will already have been prepared and the waste will be covered immediately with 3 feet of soil.

2.5.5 Periodic Cover

2.5.5.1 C&D Landfill Units

At the completion of waste placement each week, or sooner if the area of exposed waste exceeds one acre in size, a 6-inch layer of earthen material or other material as approved by the DWM will be placed over the exposed waste. This periodic cover is intended to control vectors, fire, odors, and blowing debris.

2.5.5.2 Ash Monofill

Due to the nature of the waste placed in this landfill unit, no periodic soil cover is required.

2.5.6 Intermediate Cover

2.5.6.1 C&D Landfill Units

A 12 inch layer of soil cover should be placed on all waste surfaces that have not received waste in 30 days but are below final elevation. This intermediate cover should be seeded immediately and graded such that all precipitation run-off is channeled to the surface water systems.

2.5.6.2 Ash Monofill

Unless suitable vegetation can be established on the surface of the ash a 12-inch layer of soil cover should be placed over the ash on all outer side slopes. This intermediate cover should be seeded immediately and graded such that all precipitation run-off is channeled to the surface water systems.

2.5.7 Height Monitoring

Periodically, the landfill staff will monitor landfill top and side slope elevations with a level. When such elevations approach design grades, the final top-of-waste grades will be staked to limit over-placement of waste.

2.6 WOOD WASTE PROCESSING AREA

A wood waste processing are is located to the east of the existing Area 1 C&D landfill unit (see **Figure 1**). The operation of the wood waste processing area is as follows:

Acceptable wood and yard wastes are stockpiled to an approximate height of 15 feet over an area of approximately 1 acre (approximate weight of 1,500 to 2,000 lbs.). At that time a contractor is brought in to grind the waste. Once the waste is ground and becomes mulch, it is either hauled off-site, used around the site, primarily for surface stabilization, or placed in windrows to be

given to the public or otherwise used in the future.

2.7 WHITE GOODS HANDLING AREA

A white goods handling area is located to the east of the existing Area 1 C&D landfill unit (see **Figure 1**). The operation of the white goods handling area is as follows:

Within the white goods handling area, white goods and scrap metal are stockpiled up to about 10 feet high over an approximate 100 foot by 100 foot area. Once the stockpile reaches capacity (typically every 2 to 3 months), a recycler removes Freon and hauls the white goods and scrap metal off-site to be recycled.

2.8 USED TIRE STORAGE AREA

Used tires are collected at an area near the landfill scale house (see **Figure 1**) and placed in up to three tire trailers. Once one or more trailers are full, the trailer(s) are picked up by a recycling contractor.

2.9 USED PESTICIDE CONTAINER STORAGE AREA

A sheltered storage area is located near the landfill office/maintenance building (see **Figure 1**) for used pesticide containers from local agricultural sources. Once approximately 5,000 containers have been collected, a recycling contractor grinds the containers, bags the ground plastic, and transports the plastic for recycling.

SECTION 3.0
ENVIRONMENTAL MANAGEMENT

3.1 OVERVIEW

This section reviews the overall environmental management tasks required for the successful operation of the landfill facility.

3.2 SURFACE WATER CONTROL

As used herein, the definition of "surface water" is water which results from precipitation or site run-on that has not contacted the waste.

Proper control of surface water at the landfill will accomplish the following goals:

- Prevent the run-on of surface water into the landfill unit(s) or the active face(s);
- Prevent the run-off of surface water that has come into contact with the waste (i.e. leachate);
- Limit the erosion caused by surface waters; and
- Limit sediments carried off-site by surface waters.

Separate erosion and sedimentation control plans have been provided for the various landfill units. These plans describe both short and long term engineered features and practices for preventing erosion and controlling sedimentation at this site. The following is a brief discussion of some of these features and practices, focusing more on the landfill units.

3.2.1 Surface Water Run-On Control

The perimeter berms and/or perimeter channels around the landfill unit(s) are designed to prevent the run-on of surface water from adjacent land into the landfill. Additional structures such as diversion berms, channels, down pipes, etc. carry surface water away from the landfill units.

3.2.2 Erosion Control

The serviceability of the landfill relies heavily on soil berms, barrier layers, and agricultural layers that are readily eroded by flowing water. Erosion control provisions incorporated in the landfill include the following:

- The slope of the working face must be no steeper than 5H:1V where practical to limit erosion of the periodic cover.

- Intermediate cover that has been exposed for more than 30 days must be seeded immediately and repaired when erosion features are identified.

- Drainage breaks (diversion berms, etc.) are provided on the final cover to limit the flow length of run-off.

- Water collected by each drainage break is routed to stormwater drainage channels or down pipes so that the run-off volume does not accumulate going down the slope.

- The vegetative soil layer placed over the final cover must be seeded immediately.

Additional erosion control measures have been taken within the drainage channels and at points of stormwater discharge. All final cover should be inspected regularly for erosion damage and promptly repaired.

3.2.3 Sedimentation Control

Stormwater run-off from the landfill unit(s) is conveyed to one of the on site sediment basins and/or traps. These basins and/or traps should be inspected regularly for sediment build-up or erosion damage. The basins and/or traps should be cleaned out when sediment fills the lower half of the basin.

3.3 WATER QUALITY MONITORING

The monitoring program and procedures outlined in the current Water Quality Monitoring Plan will be followed for the monitoring of site groundwater monitoring wells and surface water monitoring locations. The results of the water quality monitoring program will be placed in the facility operating record as described in **Section 1.11**.

3.4 LANDFILL GAS (LFG) MANAGEMENT - CLOSED MSW LANDFILL UNIT

Landfill gas (LFG) is produced from degradation of the municipal solid waste (MSW) placed within the closed MSW landfill unit. Due to the nature of the wastes placed within the C&D landfill unit and the ash monofill, no separate LFG management is not expected to be a concern.

3.4.1 Methane Monitoring Program

The County will implement a routine methane monitoring program to ensure that methane concentrations do not exceed 25 percent of the lower explosive limit (LEL) in facility structures, or 100 percent of the LEL at property boundaries. Gas monitoring wells will be sampled on a quarterly basis. Monitoring of facility structures is not required due to the distance and natural barriers between the structures and the closed MSW landfill.

3.4.2 Record Keeping

Results of the methane monitoring program will be placed in the facility operating record as described in **Section 1.11**.

3.4.3 LFG Contingency Plan

In the event methane concentrations exceed allowable limits, the emergency response plan will be as follows:

Open Air Areas

1. For 100% LEL at distances less than 250 feet from structures:

    a. Recalibrate equipment and recheck reading.
    b. Immediately take all necessary steps to ensure protection of human health (i.e. remove sources of ignition and limit access to the area).
    c. Call Fire Department.
    d. Notify the DWM (see **Section 1.2.2**).
    e. Notify the Consulting Engineer.
    f. Note the current weather and ground moisture conditions.
    g. Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health.
    h. Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the DWM that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

2. For 100% LEL at distances greater than 250 feet from structures:

    a. Recalibrate equipment and recheck reading.
    b. Immediately take all necessary steps to ensure protection of human health (i.e. remove sources of ignition and limit access to the area).
    c. Notify the DWM.
    d. Notify the Consulting Engineer.
    e. Note the current weather and ground moisture conditions.

Structures

1. For structures with greater than 25% LEL:

    a. Recalibrate equipment and recheck reading.
    b. Immediately take all necessary steps to ensure protection of human health as above - including immediate evacuation leaving all doors open.

c. Call Fire Department.
d. Notify the DWM.
e. Notify the Consulting Engineer.
f. Note the current weather and ground moisture conditions.
g. Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health.
h. Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the DWM that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

2. For structures with 0-25% LEL:

a. Recalibrate equipment and recheck reading.
b. Discuss with the Consulting Engineer.

3.5 VECTOR CONTROL

Due to the nature of the waste disposed of at this facility, vector control is not anticipated to be of concern. Note that the use of periodic cover in the C&D landfill unit will discourage animals from nesting in the waste.

3.6 ODOR CONTROL

Due to the nature of the waste disposed of at this facility, odor control is not anticipated to be of concern. However, if odor control becomes a problem, additional measures (such as additional cover over wastes such as drywall) will be taken to ensure odor control.

3.7 DUST CONTROL

Dust related to waste hauler traffic on the access roads will be minimized by using a water truck to limit dust on the gravel portion of the road. Dust generated by excavation of cover soil will be limited by watering the cut soil areas if accessible to the water truck. The source of water is from one of the site sediment basins.

3.8 LEACHATE SEEPS

Leachate seeps can occur due to a variety of circumstances. The goal in dealing with leachate seeps is to prevent seepage from leaving the limits of waste disposal areas and to minimize the potential for reoccurrence. If evidence of leachate seeps is observed, the County will take the following actions. Depending on the circumstances, various combinations of actions may be appropriate.

1. If leachate is observed outside of the limits of waste disposal areas, notify the

DWM (see **Section 1.2.2**).

2. Contain the flow of leachate using soil berms and/or excavation.
3. Excavate the area of seepage to attempt to allow flow into the underlying waste (i.e. break-up soil layers that may be causing the seep.).
4. For contained leachate that will not flow into underlying waste, a pump may be required to route the leachate to a tanker truck for proper disposal off-site.
5. The use of soil (particularly clay) to plug the seepage may be successful in the case where flows are minor.
6. Remove and dispose of impacted cover soils accordingly.
7. Repair landfill cover as necessary.

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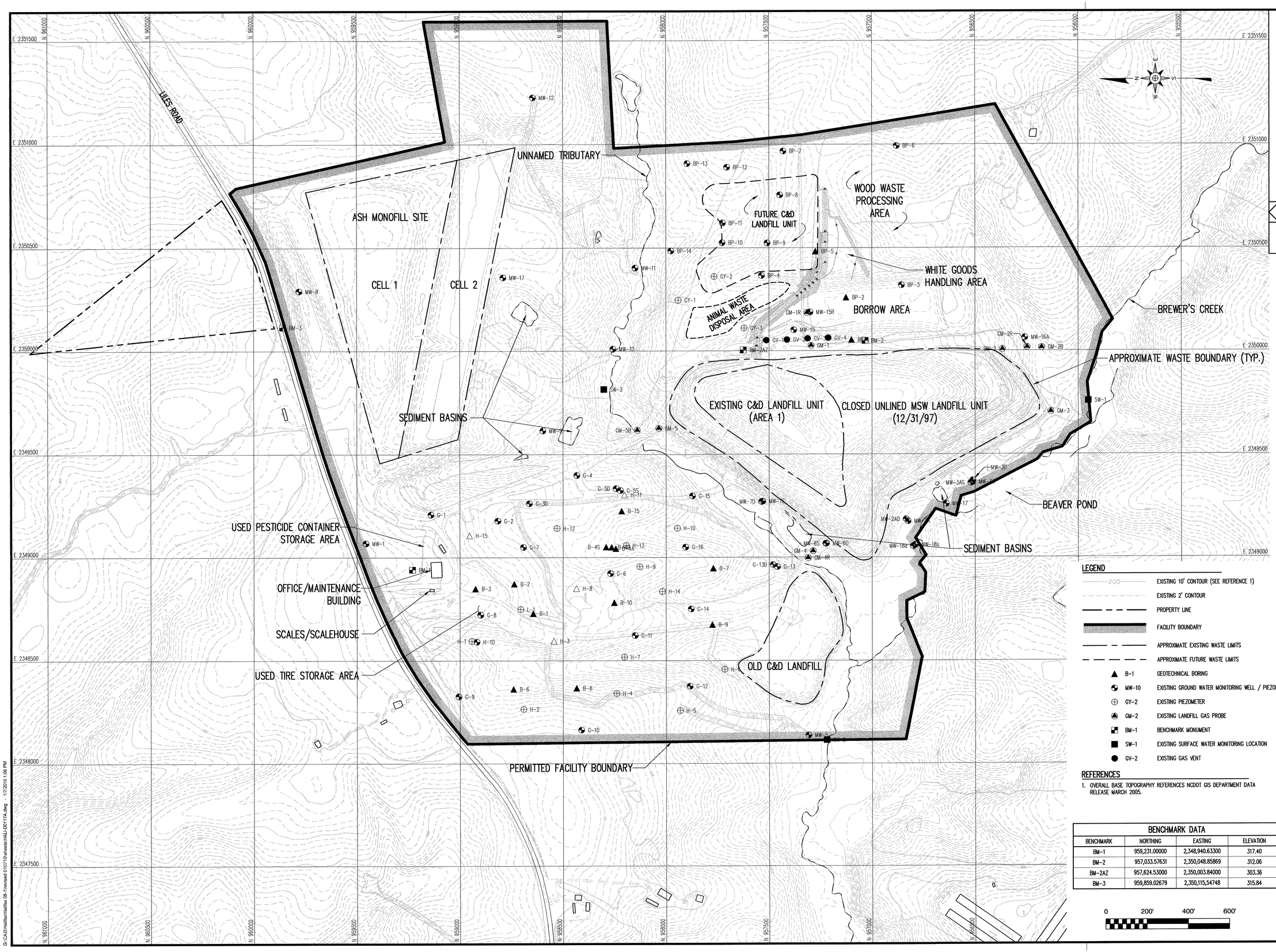

LEGEND

- EXISTING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- PROPERTY LINE
- FACILITY BOUNDARY
- APPROXIMATE EXISTING WASTE LIMITS
- APPROXIMATE FUTURE WASTE LIMITS
- B-1 GEOTECHNICAL BORING
- MW-10 EXISTING GROUND WATER MONITORING WELL / PIEZOMETER
- GY-2 EXISTING PIEZOMETER
- GM-2 EXISTING LANDFILL GAS PROBE
- BM-1 BENCHMARK MONUMENT
- SW-1 EXISTING SURFACE WATER MONITORING LOCATION
- GV-2 EXISTING GAS VENT

REFERENCES

1. OVERALL BASE TOPOGRAPHY REFERENCES NCDOT GIS DEPARTMENT DATA RELEASE MARCH 2005.

BENCHMARK DATA

BENCHMARK	NORTHING	EASTING	ELEVATION
BM-1	959,231.00000	2,348,940.63300	317.40
BM-2	957,033.57631	2,350,048.85869	312.06
BM-2AZ	957,624.53000	2,350,003.84000	303.36
BM-3	959,859.02679	2,350,115,54748	315.84

0 200' 400' 600'

DATE	NO.	REVISION
1/2010	2	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
NC Lic. NO. C-0828 (Engineering)
www.rsgengineers.com
14 N. Boylan Ave.
Raleigh, N.C. 27603
ph: 919-828-0577
fax: 919-828-3899

SEAL

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021668 PIETER K. SCHEER 2/2/10

PROJECT TITLE:

HALIFAX COUNTY LANDFILL FACILITY

DRAWING TITLE:

EXISTING AND PROPOSED LANDFILL UNITS AND SOLID WASTE MANAGEMENT ACTIVITIES

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX 08-1
SCALE: AS SHOWN	DATE: MAY 2008
FILE NAME: HALI-D0117A	
SHEET NO.	DRAWING NO. FIG. 1

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Appendix A

Waste Screening Form

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Halifax County Landfill Facility
Permit No. 42-04
(252) 586-7516

WASTE SCREENING FORM

Day / Date: _____ Time Weighed in: _____
Truck Owner: _____ Driver Name: _____
Truck Type: _____ Vehicle ID / Tag No: _____
Weight _____ Tare: _____
Waste Generator / Source: _____

Reason Load Inspected: Random Inspection _____ Staff Initials _____
Detained at Scales _____ Staff Initials _____
Detained by Operating Staff _____ Staff Initials _____

Inspection Location: _____

Approved Waste Determination Form Present? Yes _____ No _____ N/A _____

Description of Load: _____

Load Accepted (signature) _____ Date _____
Load Not Accepted (signature) _____ Date _____

Reason Load Not Accepted (complete only if load not accepted)

Description of Suspicious Contents: Color _____ Haz. Waste Markings _____
Texture _____
Drums Present _____ Smell _____
Est. Cu. Yds. Present in Load _____
Est. Tons Present in Load _____

Halifax County Emergency Management Contacted? Yes _____ No _____

Company or Authority Contacted? _____
Hazardous Materials Present: _____

Hauler Notified (if waste not accepted) Phone: Time Contacted:
Other Observations: _____

Final Disposition
Signed _____ Date _____
Waste Screening Inspector or Solid Waste Director

Attach related correspondence to this form.
File completed form in Operating Record.

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Closure and Post-Closure Plan

Halifax County C&D Landfill
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

June 2008
Revised: January 2010

RICHARDSON SMITH GARDNER & ASSOCIATES
ENGINEERING & GEOLOGICAL SERVICES

14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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HALIFAX COUNTY C&D LANDFILL

CLOSURE AND POST-CLOSURE PLAN

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SECTION 1.0
CLOSURE PLAN

1.1 OVERVIEW

This plan is intended to serve as a guide for the proposed closure. A formalized Closure Plan for Area 1 (or incremental portion thereof) will be submitted to the Solid Waste Section of the North Carolina Department of Environment and Natural Resources Division of Waste Management (DWM) for approval prior to beginning closure construction.

1.2 MAXIMUM CLOSURE AREA AND WASTE CAPACITY

A final cover grading plan (**Drawing S4**) is provided in the Permit Drawings (**Attachment G** to the Permit Application) for continued operation of Area 1 of the Halifax County C&D Landfill. Based on this drawing, the following are the estimated maximum area and capacity to be closed under this plan.

Landfill Unit	Area (Acres)	Gross Capacity (CY)	Net (Waste) Capacity (CY/Tons)
Area 1 (See Note 1)	6.5	131,267	94,545 CY 75,336 Tons

Notes:

1. The volume and tonnage figures assumed for Area 1 assume a 10% soil periodic cover usage and a conversion factor of 0.7 tons/cubic yard of waste.

Note that the underlying unlined MSW landfill unit has been previously closed in accordance with State regulations. It is estimated that this landfill unit contains approximately 900,000 tons of waste.

1.3 FINAL COVER SYSTEM

The components of the Area 1 final cover system will consist of the following components (top-down):

Alternative Final Cover System (.1627 (c) (2)):

Top Slopes (Typically 5 to 10%):

- an 18-inch thick vegetative soil layer;
- a drainage geocomposite (with drainage breaks);
- a 30-mil textured LLDPE geomembrane or geosynthetic clay liner

(GCL); and
- a 12-inch thick intermediate cover layer.

Side Slopes (Typically 4H:1V):

- a 24-inch thick vegetative soil layer.

The final cover system will be placed on prepared intermediate cover at a maximum slope of 4H:1V (minimum slopes will be 5%). A landfill gas (LFG) control system and surface water control devices will also be incorporated into the final cover. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications.

Technical specifications and construction quality assurance requirements for final cover system components can be found in **Attachments B and C**, respectively. Final cover system details are shown on **Drawing D1** (Final Cover System and LFG Management Details).

1.4 LANDFILL GAS SYSTEM

A landfill gas system is provided in the final cover design. This system includes a system of collection wells or vents placed within the waste to capture the gas and passively vent the gas. Alternatively, if desired by the County or required utility flares or an active collection system with blower and flare may be employed. The location of gas system components are shown on **Drawing S4** (Area 1 Final Cover Grading and Drainage Plan). 11 wells are currently installed within the closed MSW portion of the landfill and an additional 6 wells/vents are proposed for installation.

1.5 SURFACE WATER SYSTEMS

Precipitation falling on the cover will infiltrate into the cover or run off the cover. Short-term the run-off runs down the surface of the intermediate cover. Long-term the run-off is collected in a series of drainage breaks built into the areas covered by final cover. These drainage breaks are provided along side slopes (side slope swales) and near the upper edge of the side slopes (cap diversion berms). Water captured by side slope swales or diversion berms is routed toward one of the down pipes. Flow in the down pipes is routed to the base of the landfill and to one of the site sediment basins.

The locations of side slope swales, diversion berms, and down pipes are shown on **Drawing S4** (Area 1 Final Cover Grading and Drainage Plan).

1.5.1 Incremental Operation

During much of the life of the landfill, surface run-off will be handled by the intermediate cover system. Operations must strive to provide operational grading that encourages run-off from the intermediate cover to drain to the perimeter channels along the perimeter

berms or to areas covered by final cover. Corrugated polyethylene (CPE) piping and temporary soil berms must be installed if required to accomplish this run-off routing.

1.5.2 Required Maintenance

The surface water systems must be inspected annually and immediately after every major storm. Sediment build-up in the drainage features/devices must be cleaned out on a regular basis to promote run-off. Sediments removed can be used as daily or intermediate cover.

1.6 CLOSURE SCHEDULE

Closure activities must begin on the following schedule:

C&D Landfill Units (15A NCAC 13B.0543(c)(5)):

- No later that 30 days after the date on which the C&DLF unit receives the known final receipt of wastes;
- No later than 30 days after the date that a 10 acre or greater area of waste, is within in 15 feet of final design grades; or
- No later than one year after the most recent receipt of wastes, if the C&DLF unit has remaining capacity.

Prior to beginning closure of any landfill unit, the County will notify the DWM that a notice of the intent to close the unit has been placed in the operating record.

All closure activities shall be completed within 180 days. Exemptions and extensions may be approved by the DWM.

1.7 CLOSURE VERIFICATION

The following procedures will be implemented following closure:

- A Construction Quality Assurance (CQA) report will be submitted to the DWM. This report will describe the observations and tests used before, during, and upon completion of construction to ensure that the construction materials meet the final cover design specifications and the construction and certification requirements. The CQA report will contain as-built drawings.
- A signed certification from a registered Professional Engineer verifying that closure has been completed in accordance with the closure plan will be submitted to the DWM.

- At least one sign notifying all persons of the closing of the landfill (or incremental portions thereof) and that wastes are no longer accepted will be posted. Suitable barriers will be installed as necessary at former access points to prevent new waste from being deposited.

- Within 90 days, a survey plat, prepared by a registered Professional Land Surveyor, indicating the location and dimensions of landfill disposal areas, will be prepared.

- A notation will be recorded on the deed (through the County Register of Deed's Office) notifying any potential purchaser of the property that the land has been used as a landfill facility and that future use is restricted under the approved closure plan. A copy of the deed notation as recorded will be filed with the operating record and notification will be provided to the DWM.

SECTION 2.0
POST-CLOSURE PLAN

2.1 OVERVIEW

This Post-Closure Plan has been developed to outline steps to be taken to ensure the integrity of the landfill during its post-closure care period. The post-closure care period will last at least 30 years after final closure and, at a minimum, will consist of the following:

- Maintaining the integrity and effectiveness of final cover system;
- Performing groundwater and surface water monitoring;
- Maintaining and operating a gas monitoring system; and
- Maintaining run-on/run-off controls.

No wastes will remain exposed after closure of the landfill. Access to the closed site by the public will not pose a health hazard.

2.2 POST-CLOSURE CONTACT

All correspondence and questions concerning the post-closure care of the unit should be directed to:

Halifax County Department of Public Utilities
26 N. King Street (Public Works Building)
P.O. Box 70
Halifax, NC 27839
Phone: (252) 583-1451
Fax: (252) 593-5014.
Contact: Gwen Matthews, Interim Director

2.3 POST-CLOSURE USE

After filling operations cease at the landfill and the landfill is officially closed in accordance with the Closure Plan, the landfill will be maintained as a grassy hill. Halifax County will maintain control of the property and prevent public access to it during the post-closure period.

There may be (an) access road(s) on the final cover to allow proper maintenance during post-closure. Precise location of the access road(s) will be determined as a part of operations. Low ground pressure and rubber tire vehicles will be used for maintenance. Additionally, the County will maintain access to all site monitoring locations through the post-closure period.

2.4 MAINTENANCE

2.4.1 Repair of Security Control Devices

All security control devices will be inspected and maintained as necessary to ensure access to the site is controlled. Locks, vehicular gates, and fencing will be replaced if functioning improperly. Warning signs will be kept legible at all times and will be replaced if damaged by inclement weather or vandalism.

2.4.2 Erosion Damage Repair and Vegetation

If erosion of the final cover occurs during post-closure, the affected area will be repaired and revegetated as necessary. If necessary, rolled erosion control products (RECPs) will be used to expedite rapid revegetation of slopes and to secure topsoil in place. Revegetation (including fertilization and seeding) will be performed in accordance with the most recently approved erosion and sedimentation control plan and the North Carolina Erosion and Sediment Control Planning and Design Manual.

Mowing of the final cover surfaces will occur approximately once per year in order to help maintain a healthy stand of grasses and to cut down saplings and woody-stemmed plants.

2.4.3 Correction of Settlement, Subsidence, and Displacement

Minimum slopes of 5 percent will be maintained after settlement in order to prevent ponding and allow for proper drainage without infiltration. If vertical or horizontal displacement occurs due to differential settlement, cracks will be filled with appropriate material and final cover will be reestablished. Excessive vertical displacement is not anticipated.

2.4.4 Repair of Run-On/Run-Off Control Structures

All drainage swales, ditches, and perimeter channels will be repaired, cleaned, or realigned in order to maintain their original condition. Any culverts that are damaged will be repaired or replaced. Sediment basins/ponds will be cleaned out when sediment has reached design cleanout levels.

2.4.5 Landfill Gas System

The landfill gas system will be maintained by the County and operated in accordance with any site air quality permits. Proper operation of the system is verified through testing at the landfill gas monitoring wells.

If gas wells/vents do not function as a result of irregular settlement, accumulation of liquids (condensate, leachate, water), binding or corrosion, additional and/or replacement

wells/vents can be installed if necessary.

2.4.6 Groundwater Monitoring Wells

Procedures outlined in the current Water Quality Monitoring (WQM) Plan or subsequent revision will take precedence; however, a brief description follows. All groundwater monitoring wells have been installed with concrete pads and protective casings to prevent accidental damage by vehicles and equipment. The wells are also equipped with a locking cap to discourage vandalism. Groundwater wells will be inspected regularly (at the time of sampling) to ensure integrity. Persons inspecting a well should look at the overall condition of the well, for signs of well tampering, and cracking or degradation of the concrete pad. Should a well require replacement, the defective well should be abandoned in accordance with specifications provided in the WQM Plan and a new well installed at a location that is approved by the DWM.

2.4.7 Leachate Seeps

If evidence of leachate seeps is observed, the County will take the following actions. Depending on the circumstances, various combinations of actions may be appropriate.

1. If leachate is observed outside of the limits of waste disposal areas, notify the DWM.
2. Contain the flow of leachate using soil berms and/or excavation.
3. Excavate the area of seepage to attempt to allow flow into the underlying waste (i.e. break-up soil layers that may be causing the seep.).
4. For contained leachate that will not flow into underlying waste, a pump may be required to route the leachate to a tanker truck for proper disposal off-site.
5. The use of soil (particularly clay) to plug the seepage may be successful in the case where flows are minor.
6. Remove and dispose of impacted cover soils accordingly.
7. Repair landfill cover as necessary.

2.5 MONITORING PLAN

The closed unit will be monitored for a minimum of 30 years. Inspections of the closed landfill will be scheduled to ensure the integrity and effectiveness of the final cover system, surface water systems, groundwater monitoring system, landfill gas system, and to protect human health and the environment.

2.5.1 Inspection Frequencies

Inspections to be conducted during the post-closure care period will occur regularly as shown in **Table 2.1**.

2.5.2 Inspection Activities

Inspections will include examination of the security control devices for signs of deterioration or vandalism to ensure access to the site is limited to authorized persons. Each disposal area will be checked to ensure the integrity of the final cover system is maintained, erosion damage is repaired, vegetative cover persists, and that cover settlement, subsidence, and displacement are minimal. Additionally, the condition of the groundwater and gas monitoring systems and permanent benchmarks will be checked.

A report of findings will be made to the responsible party, including recommendations for actions deemed necessary to ensure the site continues to meet the closure performance standard.

2.5.3 Record Keeping

Records of inspections and repairs will be kept on file by the County throughout the post-closure period.

2.6 ENGINEERING CERTIFICATION

Following completion of the post-closure care period for each landfill unit, the County will notify the DWM that a certification, signed by a registered professional engineer, verifying that post-closure care has been completed in accordance with the post-closure plan, has been placed in the operating record.

TABLE 2.1: POST-CLOSURE INSPECTION FREQUENCIES

INSPECTION ACTIVITY	YEAR 1	YEARS 2-30
Security Control Devices	Quarterly	Quarterly
Vegetative Cover Condition	Quarterly[1]	Quarterly
Surface Water Systems	Quarterly[1]	Quarterly
Erosion Damage	Quarterly[1]	Quarterly
Cover Drainage System	Quarterly[1]	Semi-Annually
Cover Settlement, Subsidence, and Displacement	Quarterly[1]	Semi-Annually
Landfill Gas System	Quarterly[3]	Semi-Annually[3]
Groundwater Monitoring System	Semi-Annually	Semi-Annually[2]
Benchmark Integrity	Annually	Annually

Notes:

1. These items will be inspected after each large storm event (i.e. $\geq$ 1 inch in any 24 hours).
2. Or in accordance with groundwater monitoring schedule described in the current Water Quality Monitoring Plan.
3. Or in accordance with the current Landfill Gas Management Plan or air quality permit(s).

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SECTION 3.0
CLOSURE/POST-CLOSURE COST ANALYSIS

3.1 OVERVIEW

The purpose of this section is to provide a written estimate in current dollars of all activities and costs associated with all activities specified in the written closure and post-closure plans which have been developed for Area 1 of the Halifax County C&D Landfill.

3.2 ESTIMATED CLOSURE COSTS

Table 3.1 summarizes the estimated costs for complete closure of Area 1 (the current maximum area to be closed). This cost estimate is based on a third party providing the necessary services and includes labor in the unit prices given. The estimated closure costs will be reviewed and updated as required to reflect adjustments for inflation, rising costs of anticipated closure care, increased costs in construction or materials, or any other adjustments to the Closure Plan.

3.3 ESTIMATED POST-CLOSURE COSTS

Table 3.2 summarizes the estimated costs for the post-closure care maintenance activities. This cost estimate is based on a third party providing the necessary services and includes labor in the unit prices given. The estimated post-closure costs will be reviewed and updated as required to reflect adjustments for inflation, rising costs of anticipated post-closure care, or any other adjustments to the Post-Closure Plan.

3.4 FINANCIAL ASSURANCE MECHANISM

Halifax County intends to continue to use the Local Government Financial Test (15A NCAC 13B.1628(e)(1)(f)) to demonstrate financial assurance for this facility.

TABLE 3.1: CLOSURE COST ESTIMATE[1]

ITEM	QUANTITY[2]	UNITS	UNIT COST	ITEM COST (2010 $)
Surface Preparation	6.5	Acre	$2,000	$13,000
Landfill Gas Wells/Vents	6.5	Acre	$3,000	$19,500
30 mil Textured LLDPE Geomembrane or Geosynthetic Clay Liner (GCL) (1.1 Ac.)	47,900	SF	$0.50	$23,950
Drainage Geocomposite (1.1 Ac.)	47,900	SF	$0.50	$23,950
Vegetative Soil Layer (24")	21,000	CY	$4.00	$84,000
Erosion Control (Diversion Berms, Down Pipes, Drainage Channels, Etc.)	6.5	Acre	$5,000	$32,500
Revegetation	6.5	Acre	$1,500	$9,750
Surveying	6.5	Acre	$2,000	$13,000
			Subtotal:	$219,650
Bonds, Mobilization, & Insurance			(4% of Subtotal):	$8,786
			Subtotal:	$228,436
			Contingency (10%):	$22,844
			Construction Subtotal:	**$251,280**
Engineering	6.5	Acre	$2,000	$13,000
CQA	6.5	Acre	$5,000	$39,000
			TOTAL:	**$303,280**

Notes:

1. Assumes closure of 6.5 acres (Area 1).
2. Estimated quantities shown are in-place quantities.

TABLE 3.2: POST-CLOSURE COST ESTIMATE[1]

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL (2010 $)
Site Inspection And Record Keeping	80	HR	$75	$6,000
Revegetation (10% Total Area)	2	Acre	$1,500	$3,000
Mowing (once per year)	24	Acre	$100	$2,400
Erosion Control	1	LS	$5,000	$5,000
Gates/Fences/Access	1	LS	$2,000	$2,000
Groundwater/Surface Water Monitoring & Reporting (12 Wells/2 Surface Water Points - Semi-Annual)	14	Each	$1,000	$28,000
Methane Monitoring & Reporting (Semi-Annual After Year 1)	2	Each	$2,500	$5,000
			Subtotal:	$51,400
			Contingency (10%):	$5,140
			ANNUAL TOTAL:	$56,540
			30-YEAR TOTAL:	$1,696,200

Notes:

1. Assumes total of 24 acres (Area 1 and closed unlined MSW landfill unit).

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Erosion and Sedimentation Control Plan

Halifax County C&D Landfill
Halifax County, North Carolina

Prepared for:
Halifax County Department of Public Utilities
Halifax, North Carolina

June 2008
Revised: January 2010

RICHARDSON SMITH GARDNER & ASSOCIATES
ENGINEERING & GEOLOGICAL SERVICES

14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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HALIFAX COUNTY C&D LANDFILL
AREA 1 CONTINUED OPERATIONS

EROSION AND SEDIMENTATION CONTROL PLAN

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APPENDICES
- Appendix A Erosion and Sedimentation Control Calculations
- Appendix B Erosion and Sedimentation Control Technical Specifications (see **Attachment B**)
- Appendix C Erosion and Sedimentation Control Plans and Details (see **Attachment G**)

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HALIFAX COUNTY C&D LANDFILL
AREA 1 CONTINUED OPERATIONS

EROSION AND SEDIMENTATION CONTROL PLAN

1.0 NARRATIVE

1.1 Project Description

Halifax County plans to continue operations in Area 1 of their existing construction and demolition debris (C&D) landfill located off of Liles Road near Littleton. The continued operation of the landfill will require the disturbance of approximately 6.5 acres (Note that this acreage was included in the acreage previously permitted - see below). This plan discusses both the erosion and sedimentation control measures used on this project.

The previously approved plans for this portion of the site include:

1. Halifax County Landfill - Borrow Area No. 1 (Approved April 1996);
2. Halifax County MSW Landfill (Approved December 1996); and
3. Halifax County White Goods Handling Facility (Approved February 4, 2002).

1.2 Contact Information

1.2.1 Engineer: For questions regarding this erosion and sedimentation control plan, please contact the following:

Richardson Smith Gardner & Associates, Inc.
Attn.: Pieter K. Scheer, P.E.
14 N. Boylan Ave.
Raleigh, NC 27607
Phone: (919) 828-0577
Fax: (919) 828-3899.

1.2.2 Owner: The owner of the site and the person to contact should sediment control issues arise during the land-disturbing activity is as follows:

Halifax County Department of Public Utilities
Attn: Mr. Larry Garriss, Solid Waste Director
P.O. Box 70
Halifax, NC 27839
Phone: (252) 586-7516
Fax: (252) 586-2685.

1.3 Existing Site Conditions

The Area 1 landfill unit is a vertical expansion of an existing closed municipal solid waste (MSW) landfill unit. Existing ground surface elevations vary from El. 340 (feet) on the active and closed landfill units to El. 300 at the west end of the Area 1 landfill unit. Drainage from the Area 1 landfill unit is routed to the west to an existing sediment basin (Sediment Basin No. 1) and to the east to the existing borrow area (drains to existing rock dam).

1.4 Adjacent Areas

The Area 1 landfill unit lies within County-owned property on all sides.

1.5 Site Soils Information

The native surficial soils at the site fall under the general categoriesof Wedowee and Pacolet sandy loam according to the USGS (Halifax County) soil survey. These soils are classified as being in hydrologic soil group (HSG) "B" but have a clayey/silty substratum. Because much of the soils used at the site will be the lower clayey/silty soils, HSG "C" was conservatively used for purposes of runoff calculations.

2.0 DESIGN GUIDELINES AND PROCEDURES

The erosion and sediment control design for the landfill was conducted based on guidelines and procedures as set forth in the following references:

1. HydroCAD Software Solutions, LLC (2006), HydroCAD Stormwater Modeling System Owner's Manual - Version 8, Chocorua, NH.

2. North Carolina Division of Land Resources (2009 Update), North Carolina Erosion & Sediment Control Planning & Design Manual, Raleigh, NC.

3. Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

3.0 RUNOFF CALCULATIONS

All stormwater flow volumes were calculated using the HydroCAD computer program (utilizing USDA-NRCS (SCS) methods) and/or the Rational Method based on a 25-year 24-hour storm event. This storm event, which is a requirement of current North Carolina solid waste regulations, exceeds the 10-year event required by current North Carolina Sediment Control regulations. Rainfall quantities and/or intensities used in the analyses were derived from an analysis of design storms for the site. Drainage areas were determined using a planimeter and/or AutoCAD on topographic sheets of the project area. For each drainage area, runoff curve numbers (SCS methods) and/or runoff coefficients (Rational Method) were selected based on

ground cover conditions. Times of concentration were calculated by HydroCAD using SCS methods.

4.0 EROSION AND SEDIMENTATION CONTROL MEASURES

The following erosion and sedimentation control measures are to be constructed as part of the proposed development of the landfill. Appendices A, B, and C to this plan include calculations, technical specifications, and plans and details for each of these measures, respectively.

4.1 Sediment Basins

There is one existing permanent (Sediment Basin No. 1) sediment basin which will serve a portion of Area 1. This basin is located to the west and downslope of Area 1. This basin was modeled with the HydroCAD computer program to verify the performance of the basin.

4.2 Rock Dams

There is one existing rock dam, located at the low end of the existing borrow area, which will serve a portion of Area 1. This rock dam was modeled with the HydroCAD computer program to verify its performance.

4.3 Drainage Channels

Drainage channel calculations were conducted using a reformulation of Manning's Equation in a spreadsheet format. The calculations determine the normal depth of flow based on the peak discharge from the design storm (from HydroCAD) and assumed channel dimensions/slope(s). Both temporary and/or permanent channel linings were chosen, as appropriate, based on the calculated velocity and/or shear stress. Temporary channel linings (if specified) were designed based on the peak discharge from a 2-year 24-hour design storm.

4.4 Culverts

There is one culvert which will be used at the site to convey flow from Area 1 beneath the existing access road. This culvert is directed to the existing borrow area. This culvert was designed using HydroCAD. The outlet of this culvert was designed for outlet stabilization based on criteria set forth in E&SCP&DM, Section 6.41.

4.5 Vegetative Stabilization

Vegetative stabilization will be in accordance with the seeding schedule in the project specifications (provided as an attachment to this plan). The seeding schedule was based on Table 6.11k of E&SCP&DM which is applicable to this site.

4.6 Cap Diversion Berms

Cap diversion berms will be placed near the slope break of the final cover where the 4H:1V side slopes break to a flatter grade. Flow from the cap diversion berms is directed to the down pipes. The capacity and need for lining of cap diversion berms was checked using the same procedures as described above for drainage channels.

4.7 Down Pipes

Down pipes will be used to carry flows from diversion berms to the bottom of final cover slopes. Down pipes were designed based on an analysis of inlet and outlet control under the influence of the design storm to determine the governing headwater condition. Down pipes will be adequately anchored to the landfill side slopes by use of a soil cover and each will be outleted directly to perimeter channels or sediment basins (with rip rap outlet protection).

6.0 SCHEDULE FOR IMPLEMENTATION

All erosion control measures will be placed before any land disturbance or waste placement may begin in that portion of the site which drains to the erosion control measures. Vegetative stabilization of disturbed areas will be in accordance with the following requirements:

- Temporary or permanent ground cover (or other acceptable measure(s)) adequate to restrain erosion on erodible slopes or other areas will be provided within 21 calendar days following completion of any phase of grading.

- Permanent ground cover for all disturbed areas will be provided within 15 working days or 90 calendar days (whichever is shorter) following the completion of construction.

7.0 INSPECTION AND MAINTENANCE

All erosion and sedimentation control measures will be inspected at least once every seven calendar days and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period. A rain gauge will be maintained on the site and a record of the rainfall amounts and dates will be kept properly.

During inspections, any stormwater discharges from the site will be observed for stormwater discharge characteristics to evaluate the effectiveness of the erosion and sedimentation control measures incorporating Best Management Practices (BMPs). If visible sedimentation is leaving the disturbed limits of the site, corrective action will be taken immediately to control the discharge of sediments.

Repairs to erosion and sedimentation control measures will be made as needed and accumulated sediment removed if necessary. All sediments which are removed from erosion and

sedimentation control measures will be disposed of in an approved manner at a location to be designated by the Engineer in such a manner that further erosion and sedimentation will not occur.

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Appendix A

Erosion & Sedimentation Control Calculations

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HALIFAX COUNTY C&D LANDFILL
AREA 1 CONTINUED OPERATIONS

EROSION AND SEDIMENTATION CONTROL PLAN
APPENDIX A: EROSION AND SEDIMENTATION CONTROL CALCULATIONS

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2.0 Analysis of Design Storms
3.0 Drainage Areas and Curve Numbers ***(Rev. - 1/10)***
4.0 Stormwater Routing (HydroCAD output)*
- 25-Year 24-Hour Storm ***(Rev. - 1/10)***

5.0 Drainage Channel Analysis
- DC-1 ***(Rev. - 1/10)***
- Cap Diversion Berms ***(New - 1/10)***

6.0 Down Pipe Analysis ***(Rev. - 1/10)***
7.0 Outlet Protection Analysis ***(New - 1/10)***

*The design of culverts is included in the HydroCAD output.

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PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Drainage and E&SC Calculations - Overview

SHEET 1 OF 2
JOB NO. HALIFAX-08-1
DATE 4/27/08
COMPUTED BY PKS
CHECKED BY

Objective

To design stormwater conveyance, detention, and erosion and sedimentation control measures to remove and contain stormwater flow from the design storm. The design of these measures will be based on:

- Design storm information for the site;
- Peak discharge calculations using the Rational Method and/or USDA-NRCS (SCS) Methods; and
- Stormwater routing using USDA-NRCS (SCS) or other methods.

References

Debo, T.N., and Reese, A.J. (1995), Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL.

Federal Highway Administration (2001), Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, FHWA NHI-01-021, Second Ed., U.S. Dept. of Transportation, Washington, D.C.

Georgia Soil and Water Conservation Commission (2000), Manual for Erosion and Sediment Control in Georgia, Fifth Edition, Athens, GA.

HydroCAD Software Solutions, LLC (2006), HydroCAD Stormwater Modeling System Owner's Manual - Version 8, Chocorua, NH.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

North Carolina Division of Land Resources (2006), North Carolina Erosion & Sediment Control Planning & Design Manual, Raleigh, NC.

North Carolina Division of Water Quality (July 2005) Updated Draft Manual of Stormwater Best Management Practices, (Public Comment Version), Raleigh, NC.

Pennsylvania DEP Bureau of Watershed Protection (2000), Erosion and Sediment Pollution Control Program Manual.

USDA-NRCS (1992), Computer Program for Project Formulation Hydrology (TR-20).

USDA-NRCS (1986 & 1999 Update), Urban Hydrology for Small Watersheds (TR-55).

Virginia Department of Conservation and Recreation (1992), Virginia Erosion & Sediment Control Handbook, Third Edition, Richmond, VA.

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

Analysis The main design criteria will be to ensure that all stormwater conveyance and detention measures will be able to accommodate the runoff from the design storm. Drainage channels, culverts, etc. were designed based on the peak discharge to each measure. Detention measures were designed based on stormwater routing methods and/or State/local criteria.

Calculations

- Peak Discharge Calculations:

- USDA-NRCS (SCS) Methods:

Use HydroCAD program to determine the peak discharge to each device or structure. HydroCAD is based on the SCS unit hydrograph procedure, which is a principal component of NRCS TR-20. Alternatively spreadsheets can be used to determine flow rates using the procedures detailed in NRCS TR-55.

- Rational Method:

$$Q = CIA \qquad \text{(Malcom Eq. I -1)}$$

where:
- Q = peak discharge (cfs)
- C = rational runoff coefficient
- I = applicable rainfall intensity (in/hr) of storm event (based on time of concentration)
- A = drainage area (acres)

- Time of Concentration:

The time of concentration for use in determining the peak discharge in the NRCS and/or Rational methods can be determined by the methods detailed in NRCS TR-55 or other methods. HydroCAD uses the NRCS methods.

- Stormwater Routing:

Stormwater routing was accomplished using the HydroCAD program, which is based on USDA-NRCS (SCS) methods. Unless otherwise specified, the unit hydrograph method was used. The storm type (i.e. Type I 24-hr., Type II 24-hr., etc.) was selected as appropriate for the project location.

PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Analysis of Design Storms

SHEET 1 OF 2
JOB NO. HALIFAX-08-1
DATE 4/27/08
COMPUTED BY PKS
CHECKED BY

Objective

To compile the expected design storm depths and intensities over various return periods. These design storm values will be used in various calculations.

References

Rainfall data was obtained from the following references:

Frederick, R.H., V.A. Myers, and E.P. Anciello (1977), "Five to 60-Minute Precipitation Frequency for the Eastern and Central United States," NOAA Technical Memo. NWS HYDRO-35, National Weather Service, NOAA, U.S. Dept. Of Commerce, Silver Spring, MD.

U.S. Weather Bureau (1961), "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," U.S. Weather Bureau Technical Paper 40.

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

JOB #: HALIFAX-08-1
DATE: 5/1/08
BY: PKS
CHKD BY:

Halifax County C&D Landfill
Analysis of Design Storms

LOCATION: **Aurelian Springs, NC**

DURATION	RETURN PERIOD 2-YR P (in)	100-YR P (in)	SOURCE
5 min	0.48	0.81	NOAA HYDRO-35
15 min	1.02	1.81	NOAA HYDRO-35
60 min	1.70	3.50	NOAA HYDRO-35
2 hr to 24 hr Rainfall Events =		**USER INPUT**	USWB TP-40

DEPTH-DURATION-FREQUENCY TABLE

DURATION	RETURN PERIOD 2-YR (in)	5-YR (in)	10-YR (in)	25-YR (in)	50-YR (in)	100-YR (in)
5 min	0.48	0.55	0.60	0.68	0.75	0.81
10 min	0.80	0.93	1.02	1.17	1.29	1.40
15 min	1.02	1.19	1.32	1.51	1.66	1.81
30 min	1.35	1.65	1.86	2.16	2.40	2.64
60 min	1.70	2.12	2.41	2.84	3.17	3.50
2 hr	2.15	2.75	3.20	3.70	4.20	4.70
3 hr	2.40	3.05	3.55	4.05	4.55	5.05
6 hr	2.80	3.60	4.10	4.90	5.50	6.10
12 hr	3.40	4.20	4.95	5.90	6.50	7.30
24 hr	3.60	4.90	5.80	6.50	7.40	8.20

INTENSITY-DURATION-FREQUENCY TABLE

DURATION	RETURN PERIOD 2-YR (in/hr)	5-YR (in/hr)	10-YR (in/hr)	25-YR (in/hr)	50-YR (in/hr)	100-YR (in/hr)
5 min	5.76	6.58	7.22	8.19	8.96	9.72
10 min	4.79	5.56	6.15	7.02	7.71	8.40
15 min	4.08	4.76	5.27	6.04	6.64	7.24
30 min	2.71	3.29	3.71	4.32	4.80	5.28
60 min	1.70	2.12	2.41	2.84	3.17	3.50
2 hr	1.08	1.38	1.60	1.85	2.10	2.35
3 hr	0.80	1.02	1.18	1.35	1.52	1.68
6 hr	0.47	0.60	0.68	0.82	0.92	1.02
12 hr	0.28	0.35	0.41	0.49	0.54	0.61
24 hr	0.15	0.20	0.24	0.27	0.31	0.34

PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Drainage Areas & Curve Numbers

SHEET 1 OF 2
JOB NO. HALIFAX-08-1
DATE 1/29/10
COMPUTED BY PKS
CHECKED BY

Objective

To breakout drainage areas and associated runoff curve numbers for the drainage and erosion control plan(s). Drainage areas and runoff curve numbers will be used to determine the design flow to each stormwater conveyance and/or detention measure. Drainage areas and runoff curve numbers are tabulated in the HydroCAD output. Areas were measured by planimeter or AutoCAD on the attached plan drawings.

DRAIN AREAS & CURVE NUMBERS.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

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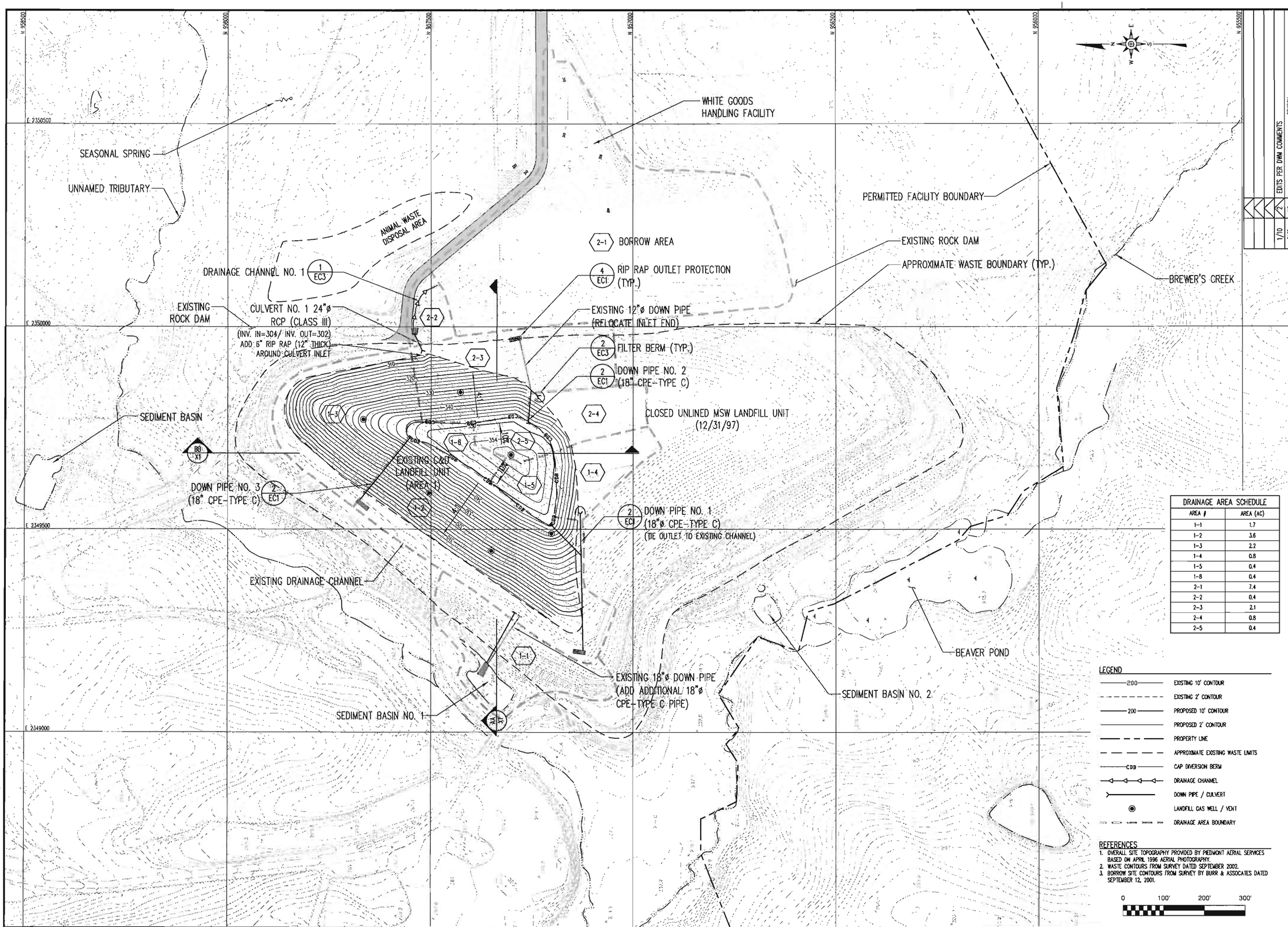

DRAINAGE AREA SCHEDULE	
AREA #	AREA (AC)
1-1	1.7
1-2	3.6
1-3	2.2
1-4	0.8
1-5	0.4
1-8	0.4
2-1	7.4
2-2	0.4
2-3	2.1
2-4	0.8
2-5	0.4

LEGEND

- 200 — EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- 200 — PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR
- PROPERTY LINE
- APPROXIMATE EXISTING WASTE LIMITS
- CDB — CAP DIVERSION BERM
- DRAINAGE CHANNEL
- DOWN PIPE / CULVERT
- LANDFILL GAS WELL / VENT
- DRAINAGE AREA BOUNDARY

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON APRIL 1996 AERIAL PHOTOGRAPHY.
2. WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW SITE CONTOURS FROM SURVEY BY BURR & ASSOCATES DATED SEPTEMBER 12, 2001.

0 100' 200' 300'

DATE	NO.	REVISION
1/10	2	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
INC LIC NO C-0208 (Engineering)
www.rsgengineers.com
14 N. Boylan Ave.
Raleigh, N.C. 27603
ph: 919-828-0577
fax: 919-828-3899

SEAL

SEAL

PROJECT TITLE:

HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:

DRAINAGE AREAS

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY:	PROJECT NO.: HALIFAX 08-1
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: HALI-D0125A	
SHEET NO.	DRAWING NO.

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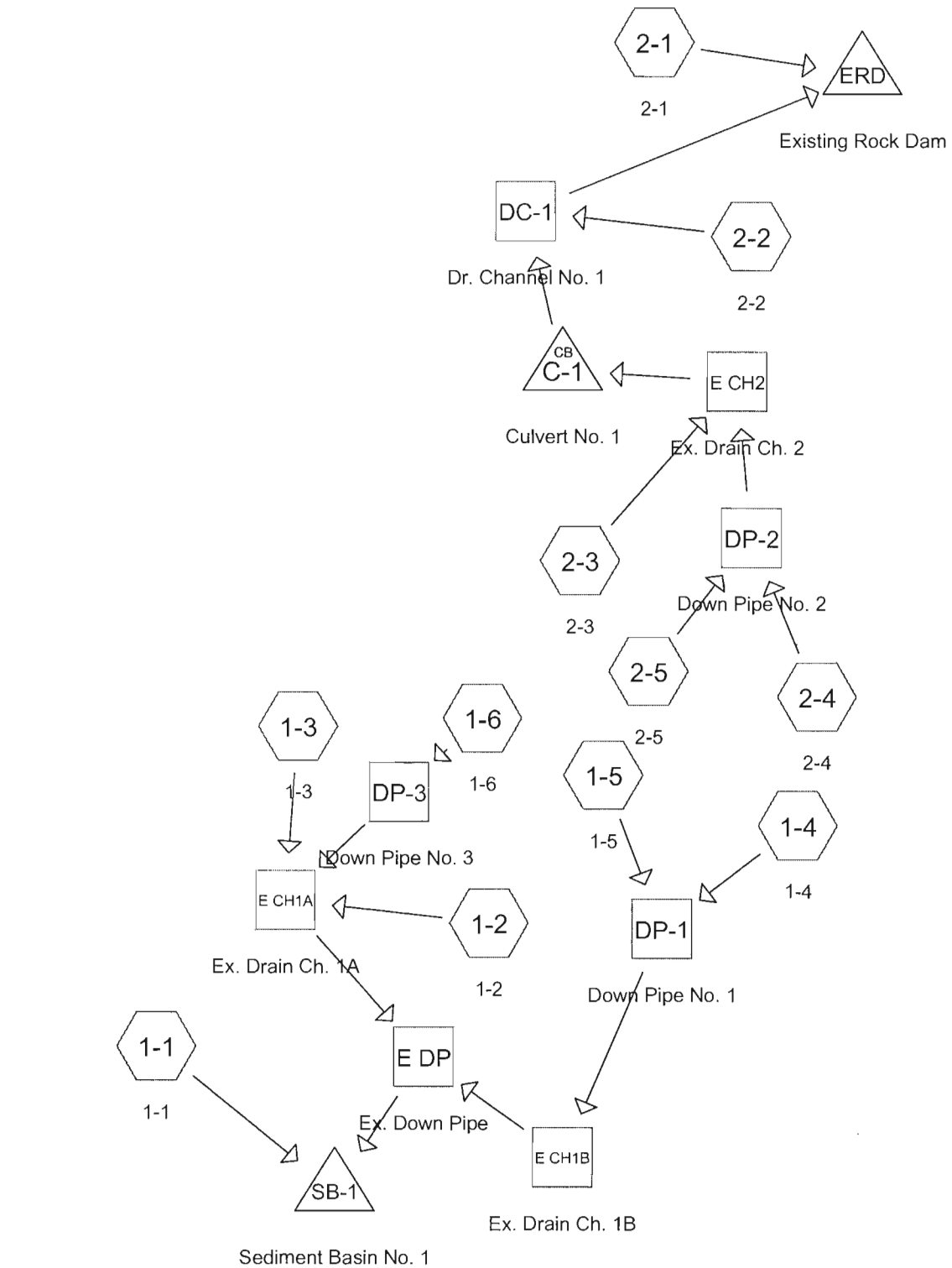


Drainage Diagram for Halifax-08-1 R2
Prepared by Richardson Smith Gardner & Assocs., Inc. 2/3/2010
HydroCAD® 8.00 s/n 004004 © 2006 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcats)
12.800	74	>75% Grass cover, Good, HSG C (1-1,1-2,1-3,1-4,1-5,1-6,2-2,2-3,2-4,2-5)
7.400	86	<50% Grass cover, Poor, HSG C (2-1)
20.200		

Time span=1.00-24.00 hrs, dt=0.05 hrs, 461 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1-1: 1-1 Runoff Area=1.700 ac Runoff Depth>3.61"
Flow Length=140' Slope=0.3300 '/' Tc=5.7 min CN=74 Runoff=10.63 cfs 0.511 af

Subcatchment 1-2: 1-2 Runoff Area=3.600 ac Runoff Depth>3.60"
Flow Length=200' Slope=0.2500 '/' Tc=8.5 min CN=74 Runoff=20.78 cfs 1.081 af

Subcatchment 1-3: 1-3 Runoff Area=2.200 ac Runoff Depth>3.60"
Flow Length=760' Tc=10.5 min CN=74 Runoff=11.77 cfs 0.660 af

Subcatchment 1-4: 1-4 Runoff Area=0.800 ac Runoff Depth>3.60"
Flow Length=180' Slope=0.0400 '/' Tc=11.2 min CN=74 Runoff=4.19 cfs 0.240 af

Subcatchment 1-5: 1-5 Runoff Area=0.400 ac Runoff Depth>3.61"
Flow Length=370' Tc=5.2 min CN=74 Runoff=2.56 cfs 0.120 af

Subcatchment 1-6: 1-6 Runoff Area=0.400 ac Runoff Depth>3.61"
Flow Length=290' Tc=4.9 min CN=74 Runoff=2.59 cfs 0.120 af

Subcatchment 2-1: 2-1 Runoff Area=7.400 ac Runoff Depth>4.88"
Flow Length=300' Slope=0.0100 '/' Tc=3.6 min CN=86 Runoff=64.34 cfs 3.012 af

Subcatchment 2-2: 2-2 Runoff Area=0.400 ac Runoff Depth>3.60"
Flow Length=100' Slope=0.0400 '/' Tc=7.0 min CN=74 Runoff=2.43 cfs 0.120 af

Subcatchment 2-3: 2-3 Runoff Area=2.100 ac Runoff Depth>3.60"
Flow Length=200' Slope=0.2500 '/' Tc=8.5 min CN=74 Runoff=12.12 cfs 0.631 af

Subcatchment 2-4: 2-4 Runoff Area=0.800 ac Runoff Depth>3.60"
Flow Length=150' Slope=0.0600 '/' Tc=8.2 min CN=74 Runoff=4.67 cfs 0.240 af

Subcatchment 2-5: 2-5 Runoff Area=0.400 ac Runoff Depth>3.61"
Flow Length=200' Tc=4.8 min CN=74 Runoff=2.60 cfs 0.120 af

Reach DC-1: Dr. Channel No. 1 Avg. Depth=0.63' Max Vel=3.99 fps Inflow=20.20 cfs 1.109 af
n=0.050 L=130.0' S=0.0462 '/' Capacity=425.45 cfs Outflow=19.83 cfs 1.108 af

Reach DP-1: Down Pipe No. 1 Avg. Depth=0.54' Max Vel=11.04 fps Inflow=6.31 cfs 0.360 af
D=18.0" n=0.020 L=340.0' S=0.1118 '/' Capacity=22.83 cfs Outflow=6.18 cfs 0.360 af

Reach DP-2: Down Pipe No. 2 Avg. Depth=0.52' Max Vel=12.90 fps Inflow=7.04 cfs 0.360 af
D=18.0" n=0.020 L=150.0' S=0.1600 '/' Capacity=27.31 cfs Outflow=6.99 cfs 0.360 af

Reach DP-3: Down Pipe No. 3 Avg. Depth=0.28' Max Vel=11.18 fps Inflow=2.59 cfs 0.120 af
D=18.0" n=0.020 L=200.0' S=0.2400 '/' Capacity=33.45 cfs Outflow=2.52 cfs 0.120 af

Reach E CH1A: Ex. Drain Ch. 1A Avg. Depth=1.69' Max Vel=3.01 fps Inflow=34.66 cfs 1.861 af
n=0.050 L=500.0' S=0.0100 '/' Capacity=46.25 cfs Outflow=32.21 cfs 1.854 af

Reach E CH1B: Ex. Drain Ch. 1B Avg. Depth=0.60' Max Vel=2.42 fps Inflow=6.18 cfs 0.360 af
n=0.050 L=200.0' S=0.0200 '/' Capacity=65.41 cfs Outflow=5.93 cfs 0.359 af

Reach E CH2: Ex. Drain Ch. 2 Avg. Depth=0.99' Max Vel=3.79 fps Inflow=19.07 cfs 0.991 af
n=0.050 L=250.0' S=0.0280 '/' Capacity=42.55 cfs Outflow=18.00 cfs 0.989 af

Reach E DP: Ex. Down Pipe Avg. Depth=0.75' Max Vel=21.41 fps Inflow=37.87 cfs 2.213 af
D=18.0" n=0.020 L=145.0' S=0.3103 '/' Capacity=76.07 cfs Outflow=37.76 cfs 2.213 af

Pond C-1: Culvert No. 1 Peak Elev=306.41' Inflow=18.00 cfs 0.989 af
24.0" x 48.0' Culvert Outflow=18.00 cfs 0.989 af

Pond ERD: Existing Rock Dam Peak Elev=295.28' Storage=103,359 cf Inflow=78.34 cfs 4.120 af
Primary=4.99 cfs 2.989 af Secondary=0.00 cfs 0.000 af Outflow=4.99 cfs 2.989 af

Pond SB-1: Sediment Basin No. 1 Peak Elev=249.98' Storage=29,247 cf Inflow=42.36 cfs 2.724 af
Primary=39.09 cfs 2.244 af Secondary=0.00 cfs 0.000 af Outflow=39.09 cfs 2.244 af

Total Runoff Area = 20.200 ac Runoff Volume = 6.855 af Average Runoff Depth = 4.07"
100.00% Pervious Area = 20.200 ac 0.00% Impervious Area = 0.000 ac

Subcatchment 1-1: 1-1

[49] Hint: Tc<2dt may require smaller dt

Runoff = 10.63 cfs @ 11.97 hrs, Volume= 0.511 af, Depth> 3.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
1.700	74	>75% Grass cover, Good, HSG C
1.700		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	140	0.3300	0.41		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.60"

Subcatchment 1-2: 1-2

Runoff = 20.78 cfs @ 12.00 hrs, Volume= 1.081 af, Depth> 3.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
3.600	74	>75% Grass cover, Good, HSG C
3.600		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	200	0.2500	0.39		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.60"

Subcatchment 1-3: 1-3

Runoff = 11.77 cfs @ 12.02 hrs, Volume= 0.660 af, Depth> 3.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
2.200	74	>75% Grass cover, Good, HSG C
2.200		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1	160	0.2500	0.37		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.60"
3.4	600	0.0100	2.97	14.84	**Channel Flow, Existing Channel** Area= 5.0 sf Perim= 7.0' r= 0.71' n= 0.040
10.5	760	Total			

Subcatchment 1-4: 1-4

Runoff = 4.19 cfs @ 12.03 hrs, Volume= 0.240 af, Depth> 3.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
0.800	74	>75% Grass cover, Good, HSG C
0.800		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	180	0.0400	0.27		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 3.60"

Subcatchment 1-5: 1-5

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.56 cfs @ 11.96 hrs, Volume= 0.120 af, Depth> 3.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
0.400	74	>75% Grass cover, Good, HSG C
0.400		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	80	0.1000	0.33		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 3.60"
1.0	180	0.0150	2.87	17.20	**Channel Flow, Cap Diversion Berm** Area= 6.0 sf Perim= 12.0' r= 0.50' n= 0.040
0.1	110	0.2000	17.28	30.53	**Circular Channel (pipe), Down Pipe** Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.020
5.2	370	Total			

Subcatchment 1-6: 1-6

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.59 cfs @ 11.96 hrs, Volume= 0.120 af, Depth> 3.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
0.400	74	>75% Grass cover, Good, HSG C
0.400		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	70	0.1000	0.32		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 3.60"
1.3	220	0.0150	2.87	17.20	**Channel Flow, Cap Diversion Berm** Area= 6.0 sf Perim= 12.0' r= 0.50' n= 0.040
4.9	290	Total			

Subcatchment 2-1: 2-1

[49] Hint: Tc<2dt may require smaller dt

Runoff = 64.34 cfs @ 11.94 hrs, Volume= 3.012 af, Depth> 4.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
7.400	86	<50% Grass cover, Poor, HSG C
7.400		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	300	0.0100	1.38		**Sheet Flow, Sheet Flow** Smooth surfaces n= 0.011 P2= 3.60"

Subcatchment 2-2: 2-2

Runoff = 2.43 cfs @ 11.98 hrs, Volume= 0.120 af, Depth> 3.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
0.400	74	>75% Grass cover, Good, HSG C
0.400		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	100	0.0400	0.24		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 3.60"

Subcatchment 2-3: 2-3

Runoff = 12.12 cfs @ 12.00 hrs, Volume= 0.631 af, Depth> 3.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
2.100	74	>75% Grass cover, Good, HSG C
2.100		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	200	0.2500	0.39		**Sheet Flow, Sheet Flow** Grass: Dense n= 0.240 P2= 3.60"

Subcatchment 2-4: 2-4

Runoff = 4.67 cfs @ 12.00 hrs, Volume= 0.240 af, Depth> 3.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
0.800	74	>75% Grass cover, Good, HSG C
0.800		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	150	0.0600	0.30		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 3.60"

Subcatchment 2-5: 2-5

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.60 cfs @ 11.95 hrs, Volume= 0.120 af, Depth> 3.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=6.50"

Area (ac)	CN	Description
0.400	74	>75% Grass cover, Good, HSG C
0.400		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	80	0.1000	0.33		**Sheet Flow, Sheet Flow** Grass: Short n= 0.150 P2= 3.60"
0.7	120	0.0150	2.87	17.20	**Channel Flow, Cap Diversion Berm** Area= 6.0 sf Perim= 12.0' r= 0.50' n= 0.040
4.8	200	Total			

Reach DC-1: Dr. Channel No. 1

[79] Warning: Submerged Pond C-1 Primary device # 1 OUTLET by 0.62'

Inflow Area = 3.700 ac, Inflow Depth > 3.60" for 25-YEAR event
Inflow = 20.20 cfs @ 12.02 hrs, Volume= 1.109 af
Outflow = 19.83 cfs @ 12.03 hrs, Volume= 1.108 af, Atten= 2%, Lag= 1.0 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.99 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 1.08 fps, Avg. Travel Time= 2.0 min

Peak Storage= 651 cf @ 12.03 hrs, Average Depth at Peak Storage= 0.63'
Bank-Full Depth= 3.00', Capacity at Bank-Full= 425.45 cfs

6.00' x 3.00' deep channel, n= 0.050
Side Slope Z-value= 3.0 '/' Top Width= 24.00'
Length= 130.0' Slope= 0.0462 '/'
Inlet Invert= 302.00', Outlet Invert= 296.00'

‡

Reach DP-1: Down Pipe No. 1

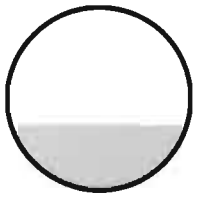
[52] Hint: Inlet conditions not evaluated

Inflow Area = 1.200 ac, Inflow Depth > 3.60" for 25-YEAR event
Inflow = 6.31 cfs @ 11.99 hrs, Volume= 0.360 af
Outflow = 6.18 cfs @ 12.01 hrs, Volume= 0.360 af, Atten= 2%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.04 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 3.59 fps, Avg. Travel Time= 1.6 min

Peak Storage= 194 cf @ 12.00 hrs, Average Depth at Peak Storage= 0.54'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 22.83 cfs

18.0" Diameter Pipe, n= 0.020 Corrugated PE, corrugated interior
Length= 340.0' Slope= 0.1118 '/'
Inlet Invert= 335.00', Outlet Invert= 297.00'



Reach DP-2: Down Pipe No. 2

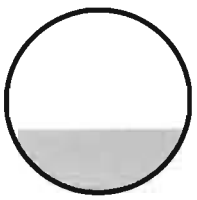
[52] Hint: Inlet conditions not evaluated

Inflow Area = 1.200 ac, Inflow Depth > 3.60" for 25-YEAR event
Inflow = 7.04 cfs @ 11.98 hrs, Volume= 0.360 af
Outflow = 6.99 cfs @ 11.98 hrs, Volume= 0.360 af, Atten= 1%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 12.90 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 4.07 fps, Avg. Travel Time= 0.6 min

Peak Storage= 82 cf @ 11.98 hrs, Average Depth at Peak Storage= 0.52'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 27.31 cfs

18.0" Diameter Pipe, n= 0.020 Corrugated PE, corrugated interior
Length= 150.0' Slope= 0.1600 '/'
Inlet Invert= 334.00', Outlet Invert= 310.00'



Reach DP-3: Down Pipe No. 3

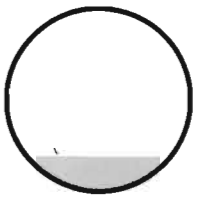
[52] Hint: Inlet conditions not evaluated

Inflow Area = 0.400 ac, Inflow Depth > 3.61" for 25-YEAR event
Inflow = 2.59 cfs @ 11.96 hrs, Volume= 0.120 af
Outflow = 2.52 cfs @ 11.96 hrs, Volume= 0.120 af, Atten= 3%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.18 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 3.40 fps, Avg. Travel Time= 1.0 min

Peak Storage= 46 cf @ 11.96 hrs, Average Depth at Peak Storage= 0.28'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 33.45 cfs

18.0" Diameter Pipe, n= 0.020 Corrugated PE, corrugated interior
Length= 200.0' Slope= 0.2400 '/'
Inlet Invert= 346.00', Outlet Invert= 298.00'



Reach E CH1A: Ex. Drain Ch. 1A

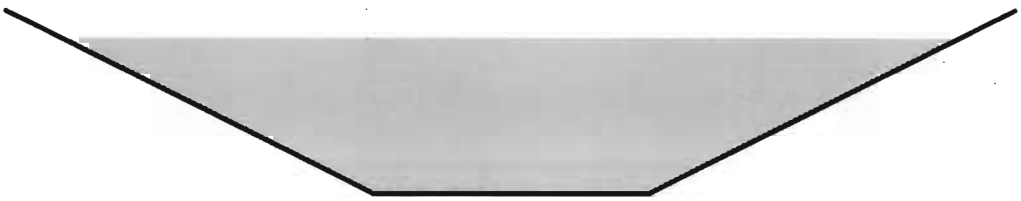
[61] Hint: Submerged 4% of Reach DP-3 bottom

Inflow Area = 6.200 ac, Inflow Depth > 3.60" for 25-YEAR event
Inflow = 34.66 cfs @ 12.00 hrs, Volume= 1.861 af
Outflow = 32.21 cfs @ 12.08 hrs, Volume= 1.854 af, Atten= 7%, Lag= 4.8 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.01 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 0.96 fps, Avg. Travel Time= 8.7 min

Peak Storage= 5,394 cf @ 12.04 hrs, Average Depth at Peak Storage= 1.69'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 46.25 cfs

3.00' x 2.00' deep channel, n= 0.050
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 500.0' Slope= 0.0100 '/'
Inlet Invert= 298.00', Outlet Invert= 293.00'



Reach E CH1B: Ex. Drain Ch. 1B

[61] Hint: Submerged 2% of Reach DP-1 bottom

Inflow Area = 1.200 ac, Inflow Depth > 3.60" for 25-YEAR event
Inflow = 6.18 cfs @ 12.01 hrs, Volume= 0.360 af
Outflow = 5.93 cfs @ 12.05 hrs, Volume= 0.359 af, Atten= 4%, Lag= 2.5 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.42 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 0.69 fps, Avg. Travel Time= 4.9 min

Peak Storage= 499 cf @ 12.03 hrs, Average Depth at Peak Storage= 0.60'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 65.41 cfs

3.00' x 2.00' deep channel, n= 0.050
Side Slope Z-value= 2.0 '/' Top Width= 11.00'
Length= 200.0' Slope= 0.0200 '/'
Inlet Invert= 297.00', Outlet Invert= 293.00'

Reach E CH2: Ex. Drain Ch. 2

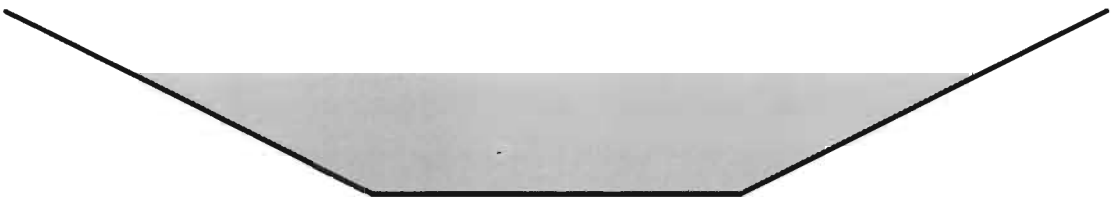
[61] Hint: Submerged 4% of Reach DP-2 bottom

Inflow Area = 3.300 ac, Inflow Depth > 3.60" for 25-YEAR event
Inflow = 19.07 cfs @ 11.99 hrs, Volume= 0.991 af
Outflow = 18.00 cfs @ 12.02 hrs, Volume= 0.989 af, Atten= 6%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.79 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.08 fps, Avg. Travel Time= 3.8 min

Peak Storage= 1,236 cf @ 12.01 hrs, Average Depth at Peak Storage= 0.99'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 42.55 cfs

3.00' x 1.50' deep channel, n= 0.050
Side Slope Z-value= 2.0 '/' Top Width= 9.00'
Length= 250.0' Slope= 0.0280 '/'
Inlet Invert= 310.00', Outlet Invert= 303.00'



Reach E DP: Ex. Down Pipe

[52] Hint: Inlet conditions not evaluated
[61] Hint: Submerged 15% of Reach E CH1A bottom
[61] Hint: Submerged 19% of Reach E CH1B bottom

Inflow Area = 7.400 ac, Inflow Depth > 3.59" for 25-YEAR event
Inflow = 37.87 cfs @ 12.08 hrs, Volume= 2.213 af
Outflow = 37.76 cfs @ 12.08 hrs, Volume= 2.213 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 21.41 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 7.16 fps, Avg. Travel Time= 0.3 min

Peak Storage= 256 cf @ 12.08 hrs, Average Depth at Peak Storage= 0.75'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 76.07 cfs

A factor of 2.00 has been applied to the storage and discharge capacity
18.0" Diameter Pipe, n= 0.020 Corrugated PE, corrugated interior
Length= 145.0' Slope= 0.3103 '/'
Inlet Invert= 293.00', Outlet Invert= 248.00'

Pond C-1: Culvert No. 1

[61] Hint: Submerged 48% of Reach E CH2 bottom

Inflow Area =	3.300 ac,	Inflow Depth >	3.60"	for	25-YEAR event
Inflow =	18.00 cfs @	12.02 hrs,	Volume=	0.989 af	
Outflow =	18.00 cfs @	12.02 hrs,	Volume=	0.989 af,	Atten= 0%, Lag= 0.0 min
Primary =	18.00 cfs @	12.02 hrs,	Volume=	0.989 af	

Routing by Stor-Ind method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 306.41' @ 12.02 hrs
Flood Elev= 307.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	304.00'	**24.0" x 48.0' long Culvert** RCP, end-section conforming to fill, Ke= 0.500 Outlet Invert= 302.00' S= 0.0417 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished

Primary OutFlow Max=17.54 cfs @ 12.02 hrs HW=306.34' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 17.54 cfs @ 5.58 fps)

Pond ERD: Existing Rock Dam

Inflow Area =	11.100 ac,	Inflow Depth >	4.45"	for	25-YEAR event
Inflow =	78.34 cfs @	11.95 hrs,	Volume=	4.120 af	
Outflow =	4.99 cfs @	12.78 hrs,	Volume=	2.989 af,	Atten= 94%, Lag= 50.0 min
Primary =	4.99 cfs @	12.78 hrs,	Volume=	2.989 af	
Secondary =	0.00 cfs @	1.00 hrs,	Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs

Peak Elev= 295.28' @ 12.78 hrs Surf.Area= 98,013 sf Storage= 103,359 cf
Flood Elev= 299.00' Surf.Area= 146,200 sf Storage= 444,400 cf

Plug-Flow detention time= 285.6 min calculated for 2.983 af (72% of inflow)
Center-of-Mass det. time= 192.0 min (991.2 - 799.2)

Volume	Invert	Avail.Storage	Storage Description
#1	294.00'	444,400 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
294.00	63,200	0	0
296.00	117,500	180,700	180,700
298.00	146,200	263,700	444,400

Device	Routing	Invert	Outlet Devices
#1	Primary	294.00'	**Rock Dam - Flow Through Stone** Head (feet) 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 Disch. (cfs) 0.000 0.660 2.810 6.680 12.500 20.510 30.940 44.020 60.000
#2	Secondary	298.00'	**143.0 deg x 20.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir** C= 2.47

Primary OutFlow Max=4.99 cfs @ 12.78 hrs HW=295.28' (Free Discharge)
└**1=Rock Dam - Flow Through Stone** (Custom Controls 4.99 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=294.00' (Free Discharge)
└**2=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond SB-1: Sediment Basin No. 1

[61] Hint: Submerged 4% of Reach E DP bottom

Inflow Area = 9.100 ac, Inflow Depth > 3.59" for 25-YEAR event
Inflow = 42.36 cfs @ 12.06 hrs, Volume= 2.724 af
Outflow = 39.09 cfs @ 12.11 hrs, Volume= 2.244 af, Atten= 8%, Lag= 3.4 min
Primary = 39.09 cfs @ 12.11 hrs, Volume= 2.244 af
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 249.98' @ 12.11 hrs Surf.Area= 9,661 sf Storage= 29,247 cf
Flood Elev= 252.00' Surf.Area= 11,000 sf Storage= 50,136 cf

Plug-Flow detention time= 109.9 min calculated for 2.244 af (82% of inflow)
Center-of-Mass det. time= 34.4 min (862.5 - 828.1)

Volume	Invert	Avail.Storage	Storage Description
#1	246.00'	50,136 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
246.00	5,660	0	0
248.00	7,050	12,710	12,710
250.00	9,688	16,738	29,448
252.00	11,000	20,688	50,136

Device	Routing	Invert	Outlet Devices
#1	Primary	246.00'	**30.0" x 50.0' long Barrel** CPP, square edge headwall, Ke= 0.500 Outlet Invert= 242.00' S= 0.0800 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	249.00'	**48.0" Horiz. Riser** Limited to weir flow C= 0.590
#3	Secondary	251.00'	**143.0 deg x 20.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir** C= 2.47

Primary OutFlow Max=38.96 cfs @ 12.11 hrs HW=249.97' (Free Discharge)
└─**1=Barrel** (Inlet Controls 38.96 cfs @ 7.94 fps)
└─**2=Riser** (Passes 38.96 cfs of 39.08 cfs potential flow)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=246.00' (Free Discharge)
└─**3=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

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PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Drainage Channel Analysis

SHEET 1 OF 6
JOB NO. HALIFAX-08-1
DATE 1/29/10
COMPUTED BY PKS
CHECKED BY

Objective

To design drainage channels, ditches, etc. to handle stormwater flow from the design storm(s). The main design criteria will be to ensure that all drainage channels, ditches, etc. will be able to accommodate the peak discharge from the design storm without overtopping and without exceeding the allowable shear stress and/or velocity of the selected channel lining.

References

Federal Highway Administration (2001), Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, FHWA NHI-01-021, Second Ed., U.S. Dept. of Transportation, Washington, D.C.

North Carolina Division of Land Resources (2006), North Carolina Erosion & Sediment Control Planning & Design Manual, Raleigh, NC.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

Pennsylvania DEP Bureau of Watershed Protection (2000), Erosion and Sediment Pollution Control Program Manual.

Analysis

The following approach is used in the design of drainage channels:

1. Determine the peak discharge from the design storm(s) (from HydroCAD or spreadsheet methods). For permanent linings (Grass, TRM, rip rap, gabions, etc.) use the peak discharge from the 25-Yr 24-Hr storm unless otherwise specified. For grass lined channels, a smaller design storm (2-Yr 24-Hr - unless otherwise specified) is used to evaluate temporary linings.
2. Input other design parameters (bottom width; side slopes; minimum freeboard, min./max. slopes; and channel lining).
3. Based on the design parameters calculate normal depth of flow, velocity, Froude number, and maximum shear stress for both max./min. slopes. Also determine the critical slope and corresponding normal depth.
4. Compare the velocity and/or shear stress to allowable values (the maximum slope values will control). If values are exceeded, revise design parameters as required.
5. Based on normal depth values and required freeboard (generally use the greater of 6 inches or 25% of the flow depth), determine the minimum channel depth and top width for both max./min. slopes (the minimum slope values will control).
6. If the channel has a significant curved reach, evaluate the shear stress and superelevation of the water surface in the bend.

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Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

Calculations

- Manning's Equation:

$$Q = \frac{1.49 A R^{2/3} S^{1/2}}{n} = AV \qquad \text{(HEC-22 Eq. 5-5)}$$

where:
- Q = discharge (cfs)
- n = Manning's roughness coefficient (See Below)
- A = cross sectional area of flow (ft^2)
- R = hydraulic radius (ft) = A/P
- P = wetted perimeter
- S = slope of channel (ft/ft)
- V = average channel velocity (ft/sec)

- Maximum Shear Stress (Tractive Force Method):

$$\tau_d = \gamma d S \qquad \text{(HEC-22 Eq. 5-13)}$$

where:
- τ_d = maximum shear stress on channel lining (lb/ft^2)
- γ = unit weight of water (62.4 lb/ft^3)
- d = maximum depth of flow (ft)
- S = channel slope (ft/ft)

- Froude Number:

$$Fr = \frac{v}{\sqrt{\frac{gA}{T}}}$$

where:
- Fr = Froude number (dimensionless)
- v = flow velocity (ft/sec)
- g = acceleration of gravity (32.2 ft/sec^2)
- A = cross-sectional area of flow (ft^2)
- T = top width of flow (ft)

Note that A/T = the hydraulic depth (D). For $Fr > 1.0$, flow is supercritical; $Fr < 1.0$, flow is subcritical; $Fr = 1.0$, flow is critical.

Critical Slope:

The critical slope (S_c) is the slope at which $Fr = 1.0$. When the slope is between $0.7S_c$ and $1.3S_c$, unstable flow may occur as small flow disturbances can initiate a change in the flow state. If slopes are within this range, consider additional freeboard.

- Manning's Roughness Coefficient (n):

Grass:

$$n = \frac{R^{1/6}}{\left[K + 19.97\log\left(R^{1.4}S^{0.4}\right)\right]}$$ (HEC-22 Eq. 5-6 - 5-10)

where:
R = hydraulic radius (ft)
K = vegetative coefficient (depending on retardance class)
= 15.8 (Class A)
= 23.0 (Class B)
= 30.2 (Class C)
= 34.6 (Class D)
= 37.7 (Class E)
S = slope of channel (ft/ft)

Rip Rap:

$$n = \frac{y^{1/6}}{21.6\log\left(\frac{y}{d_{50}}\right) + 14}$$ (PA DEP Manual Fig. 3)

where:
y = depth of flow (ft)
d_{50} = median size of rip rap (ft)

- Curved Channels (Where Applicable):

Shear Stress in Bend:

$$\tau_b = K_b \tau_d \qquad \text{(HEC-22 Eq. 5-15)}$$

where:
- τ_d = bend shear stress (lb/ft^2)
- K_b = function of R_c/B (use HEC-22 Chart 21)
- τ_d = maximum shear stress on channel lining (lb/ft^2)
- R_c = radius to the centerline of the channel (ft)
- B = bottom width of channel (ft)

Superelevation at Outside of Bend:

$$\Delta d = 0.5\frac{V^2 T}{gR_c} \qquad \text{(HEC-22 Eq. 5-11 modified)}$$

where:
- Δd = superelevation of water surface between the outer channel bank and the centerline of the channel (avg. water surface before bend) (ft)
- V = average channel velocity (ft/sec)
- T = top width of flow (ft)
- g = acceleration of gravity (32.2 ft/sec^2)
- R_c = radius to the centerline of the channel (ft)

- Allowable Shear Stress/Velocity:

Grass-Lined Channels:

For grass-lined channels, an allowable velocity approach is applicable for slopes flatter than 10%. For slopes of 10% and steeper appropriate permanent linings should be used. For use in the evaluation of curved channels, the following allowable shear stress values (lb/ft^2) can be assumed based on retardance class:

Class A:	3.70
Class B:	2.10
Class C:	1.00
Class D:	0.60
Class E:	0.35

Rip Rap-Lined Channels:

For rip rap-lined channels, an allowable velocity approach is applicable for slopes flatter than 10% (see attached table). For slopes of 10% or steeper, use the following equation:

$$\tau_{allow} = 4 \times d_{50} \qquad \text{(HEC-22 Eq. 5-17)}$$

where: τ_{allow} = allowable shear stress (lb/ft^2)
d_{50} = median size of rip rap (ft)

Reno Mattress or Gabion-Lined Channels:

For Reno mattress or gabion-lined channels, use allowable velocity for slopes flatter than 10% and allowable shear stress for slopes of 10% or steeper (see attached table).

Riprap Gradation, Filter Blanket Requirements, Maximum Velocities

	Graded Rock Size (in)			Filter Blanket Requirements**		
NSA No.	Max.	d_{50}*	Min.	Size NSA No.	Placement Thickness	V_{max} (ft/sec
R-1	1.5	.75	No. 8	FS-1	N/A	2.5
R-2	3	1.5	1	FS-1	N/A	4.5
R-3	6	3	2	FS-1	3	6.5
R-4	12	6	3	FS-2	4	9.0
R-5	18	9	5	FS-2	6	11.5
R-6	24	12	7	FS-3	8	13.0
R-7	30	15	12	FS-3	10	14.5

* The d_{50} stone size is the size exceeded by 50% of the total weight of the tonnage shipped (i.e. 50% by weight shall consist of pieces larger than the d_{50} stone size")

** This is a general standard. Soil conditions at each site should be analyzed to determine actual filter size. A suitable woven or non-woven geotextile underlayment, used according to manufacturer's recommendations, may be substituted for the filter stone

Ref: PA DEP Manual Table 9

Maximum Permissible Velocities for Reno Mattress & Gabions

Type	n	Thickness Inches	Rock Fill Gradation (in)	Permissible* Velocity (fps)	Permissible** Shear Stress (lb/ft^2)
Reno Mattress	.025 - .030	6	3 - 6	8.0	8.35
	.025 - .030	6 - 10	3 - 6	12.0	8.35
	.025 - .030	10 - 12	3 - 6	15.0	8.35
	.025 - .030	12 - 18	4 - 6	18.0	8.35
Gabion	.027	>18	5 - 9	22.0	8.35

* Permissible velocities may be increased by the introduction of sand mastic grout. Refer to manufacturer's recommendations/specifications for permissible velocities and for recommendations regarding filters or geotextile fabric underlayment when using Reno mattresses or gabions for channel linings

** Based on vegetation completely grown.

Ref: PA DEP Manual Table 13

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Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 6 / 6
JOB #: HALIFAX-08-1
DATE: 1/29/10
BY: PKS
CHKD BY:

Halifax County C&D Landfill - Area 1
Drainage Channel Analysis (Rip Rap Lined)

Channel No. DC-1

Design Parameters:

PEAK DISCHARGE, Q25 = 20.2 ft^3/s Source: HydroCAD 25-Yr 24-Hr

Bottom Width, B = 6.0 ft
Left Side Slope, z_1 = 3.0 horizontal :1 vertical
Right Side Slope, z_2 = 3.0 horizontal :1 vertical
Minimum Freeboard = 0.5 ft

Maximum Channel Slope, S_{max} = 0.050 ft/ft
Minimum Channel Slope, S_{min} = 0.040 ft/ft

Rip Rap Lining:
D_{50} = 0.50 ft
V_{allow} = 9.0 ft/sec
τ_{allow} = 2.0 lb/ft^2

Normal Depth

Depth of Flow (Norm. Depth) Y_n ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Average Velocity V_n ft/s	Flow Rate Q ft^3/s	Froude Number F_r (Normal) #	Maximum Shear Stress τ_d lb/ft^2	Allowable Velocity (V) or Sh. Stress (S) Used?	Factor of Safety V_{allow}/V_n or τ_{allow}/τ_d	Comment
Maximum Slope:													
0.66	0.056	5.27	10.17	0.52	9.96	0.53	3.82	20.1	0.93	**2.1**	V	2.4	**O.K.**
Minimum Slope:													
0.70	0.055	5.67	10.43	0.54	10.20	0.56	3.61	20.5	0.85	**1.7**	V	2.5	**O.K.**

Critical Depth

Depth of Flow (Crit. Depth) Y_c ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Section Factor $Z=AD^{1/2}$ $ft^{2.5}$	Flow Rate Q ft^3/s	Average Velocity V_c ft/s	Froude Number F_r (Critical) #	Uniform-Flow Critical Slope S_c ft/ft	Comment
0.63	0.057	4.97	9.98	0.50	9.78	0.51	3.54	20.1	4.05	1.00	0.061	**Slopes Near Sc - Check Freeboard.**

Determination of Minimum Channel Depth & Top Width

Maximum Slope		Minimum Slope	
Minimum Channel Depth ft	Minimum Top Width T ft	Minimum Channel Depth ft	Minimum Top Width T ft
1.16	12.96	1.20	13.20

Objective To design down pipes to handle the peak discharge from the design storm.

Reference Debo, T.N., and Reese, A.J. (1995), Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

Analysis The following approach is used in the design of down pipes:

1. Determine the peak discharge from the design storm(s). Use the Rational Method.

2. For each pipe size, determine the maximum area (A), to handle the predicted peak discharge (Q) with an added factor of safety. Analyze down pipes based on partial flow to determine flow depth and velocity then compare the full flow capacity of each pipe size with the calculated peak flow rate to verify the desired factor of safety. Analyze down pipe inlets as a culverts under inlet control.

Calculations

- Down Pipe Inlets (Inlet Control):

Determine Q_{max}:

For $Z \leq D$:

$$Q_{max} = 0.372 C_d D (Z)^{3/2}$$ (Malcom Equation III-13)

For $Z > D$:

$$Q_{max} = 0.0437 C_d D^2 \left(Z - \frac{D}{24} \right)^{1/2}$$ (Malcom Equation III-13)

where:
Q_{max} = flow capacity of inlet (cfs)
Z = height of water above pipe invert (ft)
= allowable headwater depth (HW)
C_d = coefficient of discharge
D = inside diameter of pipe (in)

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14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

Determine Factor of Safety (FS):

$$FS = \frac{Q_{max}}{Q}$$

Iterate the drainage area (A) to each inlet such that $Q_{max}/Q \geq$ the desired factor of safety.

- Down Pipes:

Determine Flow Capacity of Pipe:

$$Q_{max} = \frac{0.463 D^{8/3} S^{1/2}}{n} \qquad \text{(D\&R Equation 8.24)}$$

where:
Q_{max} = flow capacity of pipe (cfs)
D = inside diameter of pipe (ft)
S = pipe slope (ft/ft)
n = Manning's roughness coefficient

Determine Factor of Safety (FS):

$$FS = \frac{Q_{max}}{Q}$$

Iterate the drainage area (A) to each drainage structure such that $Q_{max}/Q \geq$ the desired factor of safety.

Determine Flow Depth:

$$h = \frac{1}{2}\left(1 - \cos\left(\frac{\theta}{2}\right)\right) D \qquad \text{(D\&R Equation 8.29)}$$

where:
h = flow depth (inches)
θ = central angle

$$\theta = \frac{3\pi}{2}\left[1 - \left(1 - (\pi K)^{1/2}\right)^{1/2}\right]^{1/2} \qquad \text{(D\&R Equation 8.28)}$$

K = constant

$$K = 0.673QnD^{-8/3}S^{-1/2}$$ (D&R Equation 8.27)

Determine Flow Velocity:

$$V = \frac{Q}{A} = \frac{Q}{D^2 \frac{(\theta - \sin\theta)}{8}}$$ (D&R Equation 8.30 for "A")

where: V = flow velocity (ft/sec)
A = cross-sectional area of flow (ft^3)

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Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 4 / 4
JOB #: HALIFAX-08-1
DATE: 1/29/10
BY: PKS
CHKD BY:

Halifax County C&D Landfill - Area 1
Down Pipe Analysis (CPE Pipe)

Input Parameters:

Manning's Rougness Coefficient =	0.020	--> CPE Pipe (Type S - Use 0.012; Type C - Use 0.02)
Runoff Coefficient =	0.60	Conservative
Rainfall Intensity =	8.19	IN/HR ---> 25 YR - 5 MIN STORM
Allowable Headwater Depth (Above Pipe Invert) (Down Pipe Inlets) =	3.0	FEET
Orifice Coef. Of Discharge (Down Pipe Inlets) =	0.6	TYPICAL

Down Pipe Inlets

ID	Drainage Area (Each Inlet) (AC)	Runoff Volume (Q) (CFS)	Pipe I.D. (IN)	X-Sectional Area (SF)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 1.10)
Max. Area - 12"	1.10	5.41	12.0	0.79	5.97	1.10
Max. Area - 15"	1.65	8.11	15.0	1.23	9.09	1.12
Max. Area - 18"	2.35	11.55	18.0	1.77	12.74	1.10
Max. Area - 24"	3.90	19.16	24.0	3.14	21.36	1.11

Down Pipes

ID	Drainage Area (AC)	Runoff Volume (Q) (CFS)	Pipe I.D. (IN)	Pipe Slope (%)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 1.10)	K (CONSTANT)	θ (< 265°)	Flow Depth (IN)	Flow Area (SF)	Flow Velocity (FPS)
Max. Area - 12"	1.35	6.63	12.0	10	7.32	1.10	0.282	235	8.78	0.62	10.77
Max. Area - 15"	2.45	12.04	15.0	10	13.27	1.10	0.283	235	10.98	0.96	12.50
Max. Area - 18"	3.95	19.41	18.0	10	21.58	1.11	0.280	234	13.09	1.38	14.10
Max. Area - 24"	8.55	42.01	24.0	10	46.48	1.11	0.282	235	17.52	2.46	17.09

MIN.

PROJECT Halifax County C&D Landfill - Area 1

SUBJECT Outlet Protection Analysis

SHEET 1 OF 4
JOB NO. HALIFAX-08-1
DATE 1/29/10
COMPUTED BY PKS
CHECKED BY

Objective To design outlet protection for culverts and/or drainage channels based on the maximum flow from the design storm. Rip rap aprons are applicable when the Froude Number (Fr) is less than or equal to 2.5 (Debo and Reese). For higher Froude Numbers, rip rap outlet basins, baffled outlets, and/or other methods are more appropriate.

Reference

Debo, T.N., and Reese, A.J. (1995), Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL, Section 8.11 - pp. 289-290; Section 12.6 - pp. 523-526.

Federal Highway Administration (2000), Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulic Engineering Circular No. 14, FHWA EPD-86-110, Metric Ed., U.S. Dept. of Transportation, Washington, D.C.

North Carolina Division of Land Resources (2006), North Carolina Erosion & Sediment Control Planning & Design Manual, Raleigh, NC.

Analysis For each outlet, determine the Froude Number (Fr) based on the pipe Manning's number, diameter, slope, and design discharge. Use the methods described in Section 8.11 of Debo and Reese. Select the method of outlet protection, as appropriate, and perform design calculations.

Rip Rap Aprons:

If Fr $\leq$ 2.5, a rip rap apron may be used. The following design approach is based on Section 12.6 of Debo and Reese and Section 8.06 of the NC Erosion & Sediment Control Planning and Design Manual:

1. Determine the tailwater condition and select the appropriate design chart.
2. Using the appropriate design chart, determine the d_{50} rip-rap size and minimum apron length (La) based on the maximum design flow (Q), flow depth (d), and/or velocity (v) (depending on whether the pipe is flowing full or partially full).
3. Using the same chart, determine apron dimensions.
4. Determine the maximum stone diameter: $d_{max} = 1.5 \times d_{50}$
5. Determine the apron thickness:
   Thickness = $1.5 \times d_{max}$ (No Filter Geotextile)
   Thickness = $1.5 \times d_{50}$ (With Filter Geotextile)

Other Methods:

If Fr > 2.5, consider the use of a rip rap basin, baffled outlet, or other device. Design method according to FHA guidelines using HY8-Energy program (or other documented source).

OUTLET PROTECTION.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 2 / 4
JOB #: HALIFAX-08-1
DATE: 1/29/10
BY: PKS
CHKD BY:

Halifax County C&D Landfill - Area 1
Outlet Protection Analysis - Rip Rap Aprons (Circular Pipe)

Rip Rap Aprons:

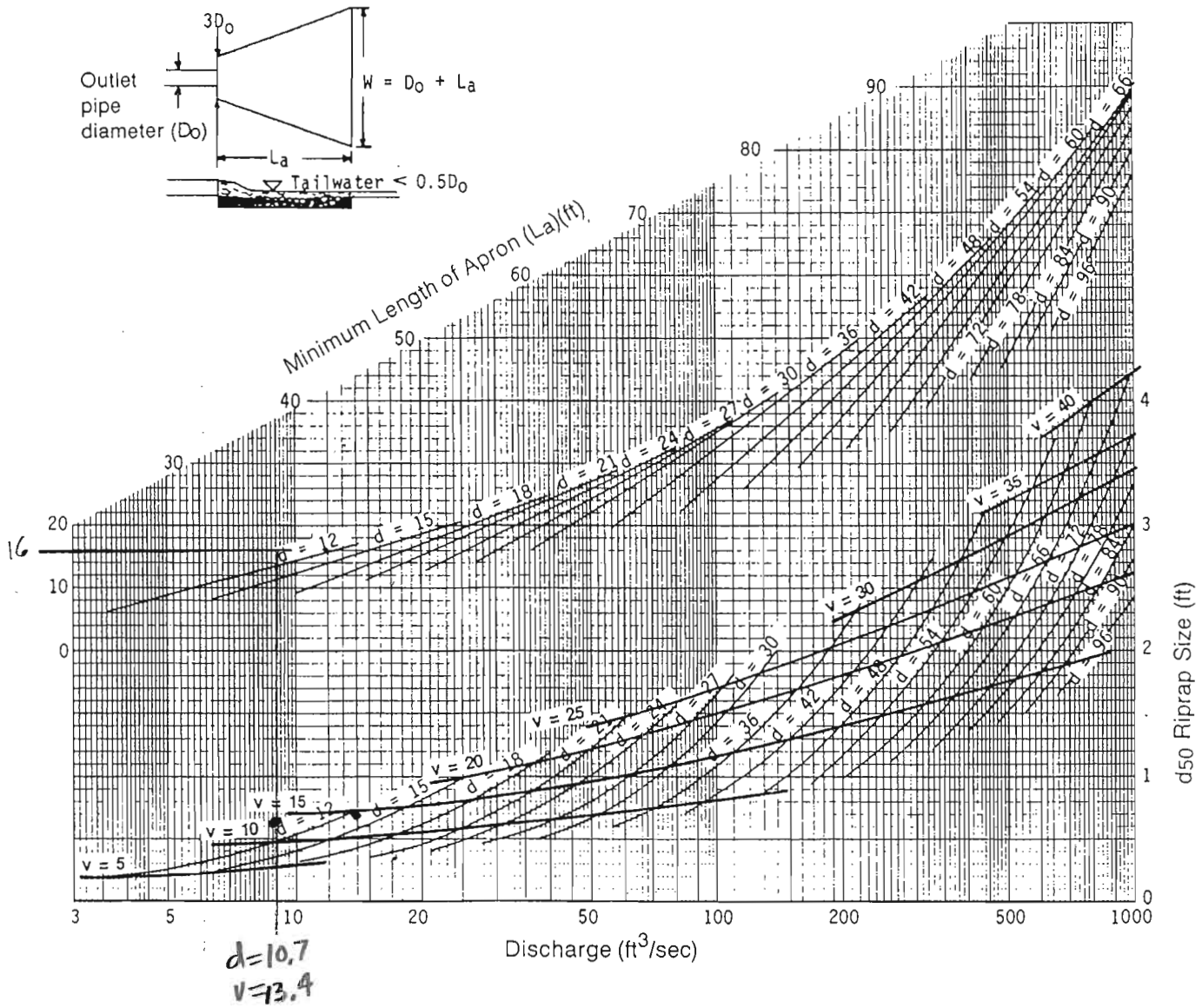
	Outlet				
	Ex. Down Pipe (x2)	**Down Pipe 1**	**Down Pipe 2**	**Down Pipe 3**	**Culvert No. 1**
Pipe Type:	CPE - Type C	CPE - Type C	CPE - Type C	CPE - Type C	Concrete
Manning's Coefficient:	0.012	0.012	0.012	0.012	0.012
Diameter (D_O) (in) =	18	18	18	18	24
Slope (%) =	4	4	4	4	4
Design Discharge (cfs) =	**19.0**	**6.2**	**7.0**	**2.5**	**18.1**
Source of Discharge Data:	HydroCAD 25-Yr 24-Hr	HydroCAD 25-Yr 24-Hr	HydroCAD 25-Yr 24-Hr	HydroCAD 25-Yr 24-Hr	HydroCAD 25-Yr 24-Hr
K =	0.267	0.087	0.098	0.035	0.123
θ (degrees) =	227	150	156	115	168
Flow Depth (d) (in) =	**12.6**	**6.7**	**7.1**	**4.2**	**10.7**
Flow Area (ft^2) =	1.3	0.6	0.7	0.3	1.4
Flow Velocity (v) (ft/sec) =	**14.4**	**10.4**	**10.8**	**8.0**	**13.4**
Froude Number =	2.47	2.45	2.46	2.38	2.50
Rip Rap Aprons Applicable?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Tailwater Condition (Low or High)*:	High	Low	Low	Low	Low
d_{50} (ft)** =	**0.50**	**0.50**	**0.50**	**0.50**	**0.75**
d_{max} (ft) =	0.75	0.75	0.75	0.75	1.13
Apron Thickness (X) (ft):	-----	-----	-----	-----	-----
No Geotextile:	1.13	1.13	1.13	1.13	1.69
With Geotextile:	**0.75**	**0.75**	**0.75**	**0.75**	**1.13**
Apron Dimensions (ft):	-----	-----	-----	-----	-----
Length (La)** =	**34**	**10**	**10**	**10**	**16**
Width (W) =	**15.1**	**Channel Width** ***	**Channel Width** ***	**Channel Width** ***	**18.0**

*Tailwater Conditions: Low: $Tw < 0.5D_O$; High: $Tw > 0.5D_O$

** Value from Chart.

*** Flow depth values fall below range of chart. Assume 10' length by channel width.

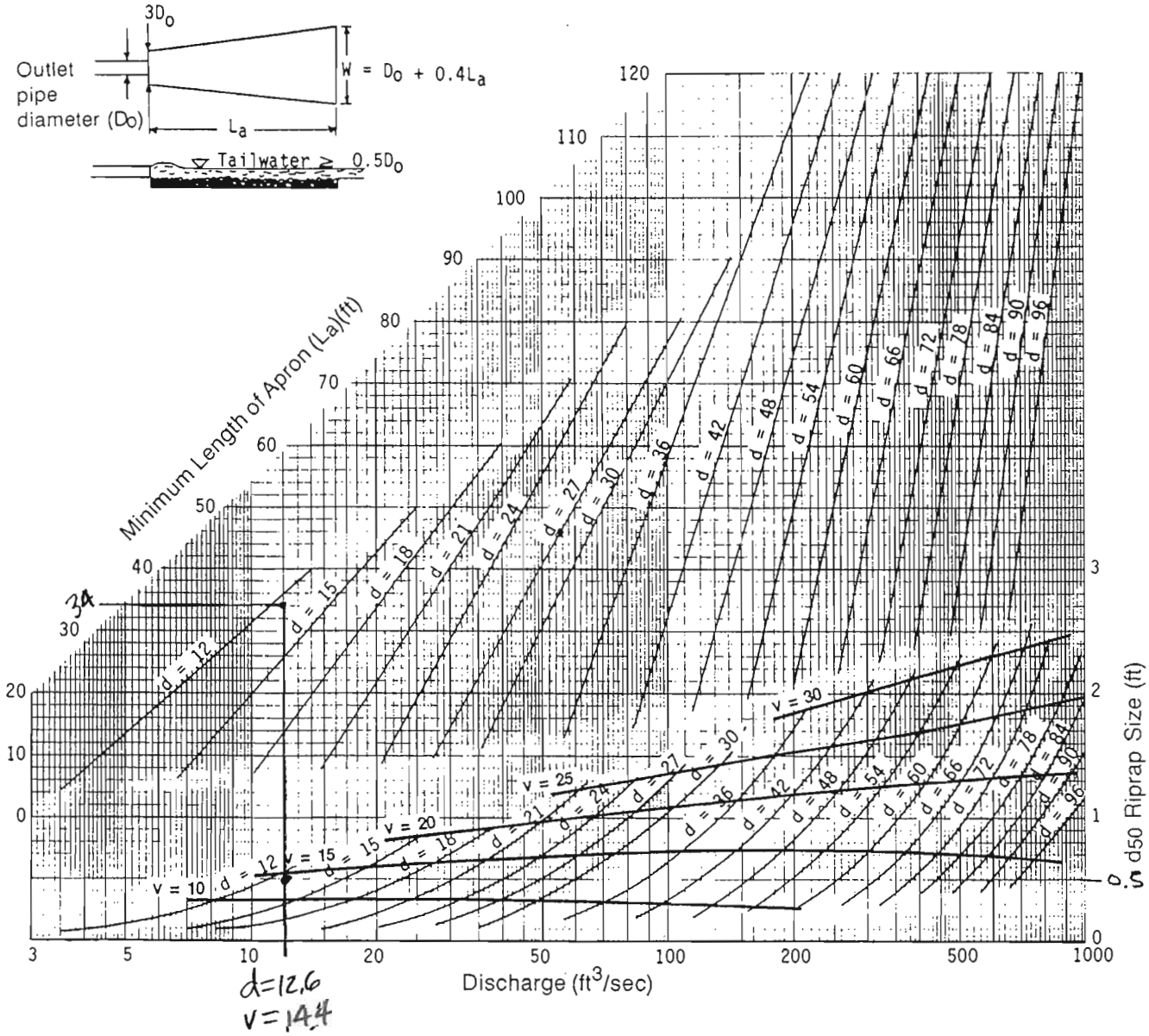
3/4



Curves may not be extrapolated.

Figure 8.06a Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).

4/4



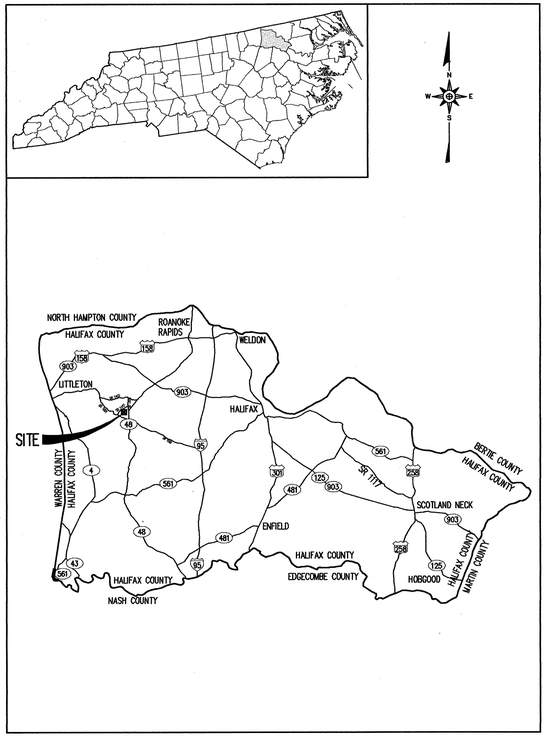
Curves may not be extrapolated.

Figure 8.06b Design of outlet protection from a round pipe flowing full, maximum tailwater condition ($T_w \geq 0.5$ diameter).

HALIFAX COUNTY, NORTH CAROLINA
DEPARTMENT OF PUBLIC UTILITIES

HALIFAX COUNTY C&D LANDFILL
AREA 1 CONTINUED OPERATIONS
PERMIT DRAWINGS

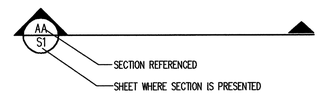
JUNE 2008
REVISED: JANUARY 2010



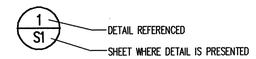
SITE LOCATION MAP
NOT TO SCALE

SHEET NO.	DRAWING NO.	TITLE	REVISION NO.
1	–	TITLE – COVER SHEET	2
2	S1	EXISTING CONDITIONS	2
3	S2	AREA 1 PERMITTED INTERMEDIATE COVER GRADES	2
4	S3	C&D LANDFILL DEVELOPMENT PLAN	2
5	S4	AREA 1 FINAL COVER GRADING AND DRAINAGE PLAN	2
6	D1	FINAL COVER AND LANDFILL GAS MANAGEMENT DETAILS	2
7	EC1	EROSION AND SEDIMENTATION CONTROL DETAILS (SHEET 1 OF 2)	2
8	EC2	EROSION AND SEDIMENTATION CONTROL DETAILS (SHEET 2 OF 2)	2
9	X1	ENGINEERING CROSS SECTIONS	2
10	P1	PHASING PLAN	2

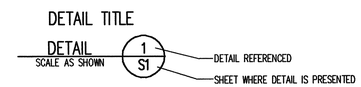
STANDARD SECTION LOCATION CALLOUT (SHEET AND DETAIL)



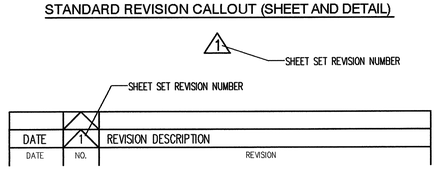
STANDARD DETAIL CALLOUT



STANDARD DETAIL LABEL AND CALLOUT



STANDARD REVISION CALLOUT (SHEET AND DETAIL)



NO.	DATE	REVISION
2	1/10	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
14 N. Boylan Ave.
Raleigh, N.C. 27603
NC LIC. NO. C-0828 (Engineering)
www.rsgengineers.com
ph: 919-828-0577
fax: 919-828-3899

NORTH CAROLINA PROFESSIONAL SEAL 021665 ENGINEER PIETER K. SCHEER 3/2/10

FILE NAME
HALI-D0106A

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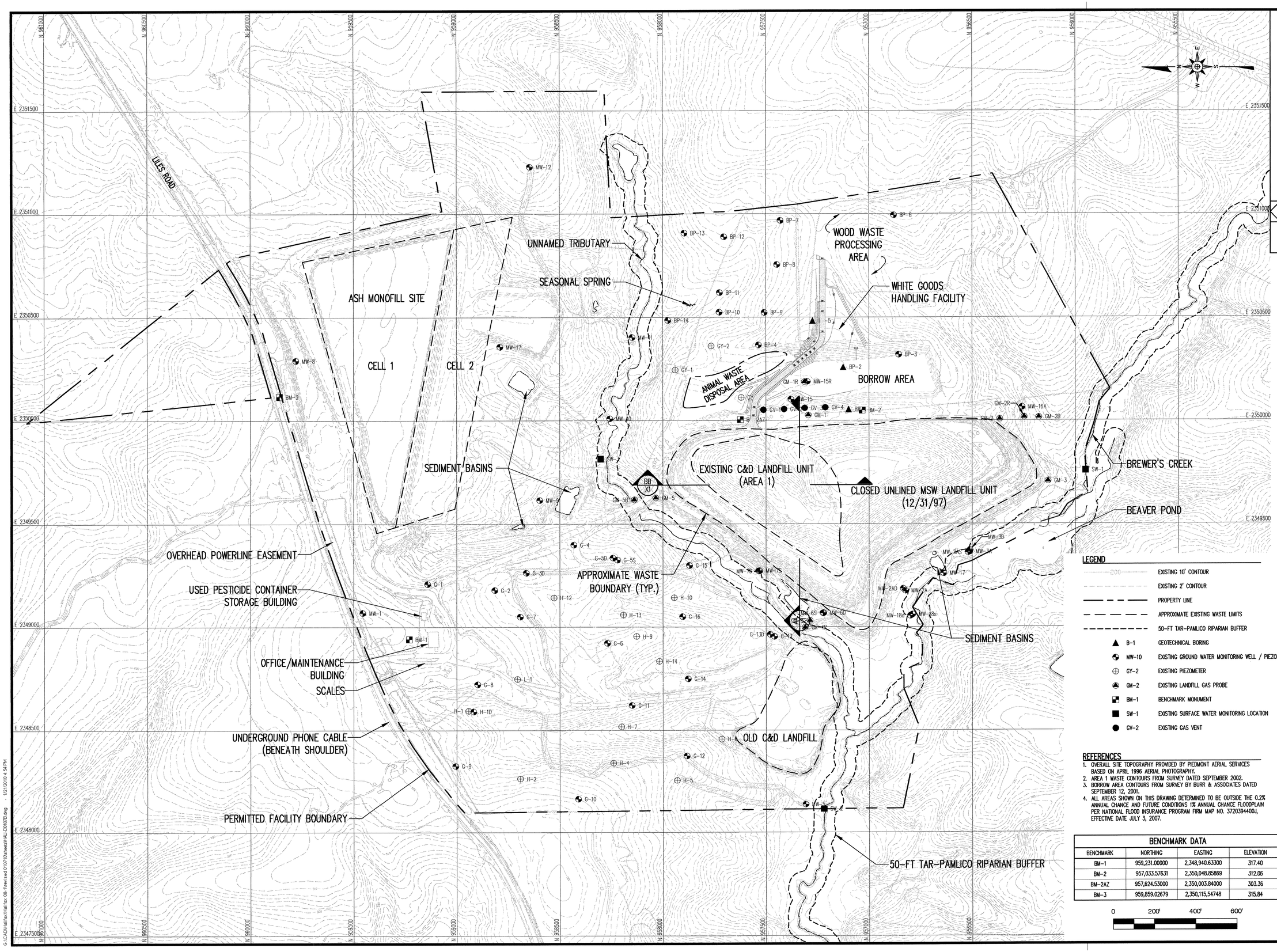

LEGEND

- 200 — EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- PROPERTY LINE
- APPROXIMATE EXISTING WASTE LIMITS
- 50-FT TAR-PAMLICO RIPARIAN BUFFER
- ▲ B-1 — GEOTECHNICAL BORING
- MW-10 — EXISTING GROUND WATER MONITORING WELL / PIEZOMETER
- GY-2 — EXISTING PIEZOMETER
- GM-2 — EXISTING LANDFILL GAS PROBE
- BM-1 — BENCHMARK MONUMENT
- SW-1 — EXISTING SURFACE WATER MONITORING LOCATION
- GV-2 — EXISTING GAS VENT

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON APRIL 1996 AERIAL PHOTOGRAPHY.
2. AREA 1 WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW AREA CONTOURS FROM SURVEY BY BURR & ASSOCIATES DATED SEPTEMBER 12, 2001.
4. ALL AREAS SHOWN ON THIS DRAWING DETERMINED TO BE OUTSIDE THE 0.2% ANNUAL CHANCE AND FUTURE CONDITIONS 1% ANNUAL CHANCE FLOODPLAIN PER NATIONAL FLOOD INSURANCE PROGRAM FIRM MAP NO. 3720394400J, EFFECTIVE DATE JULY 3, 2007.

BENCHMARK DATA

BENCHMARK	NORTHING	EASTING	ELEVATION
BM-1	959,231.00000	2,348,940.63300	317.40
BM-2	957,033.57631	2,350,048.85869	312.06
BM-2AZ	957,624.53000	2,350,003.84000	303.36
BM-3	959,859.02679	2,350,115.54748	315.84

0 200' 400' 600'

REVISION	NO.	DATE
EDITS PER DWM COMMENTS	2	1/10
EDITS PER DWM COMMENTS	1	8/09

RICHARDSON SMITH GARDNER & ASSOCIATES
14 N. Boylan Ave. Raleigh, N.C. 27603
ph: 919-828-0577 fax: 919-828-3899
www.rsgengineers.com

SEAL
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021066 PIETER K. SMITH 8/12/10

PROJECT TITLE:
HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:
EXISTING CONDITIONS

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX091
SCALE: AS SHOWN	DATE: JUNE 2009
FILE NAME: HALI-D0107B	
SHEET NO. 2	DRAWING NO. S1

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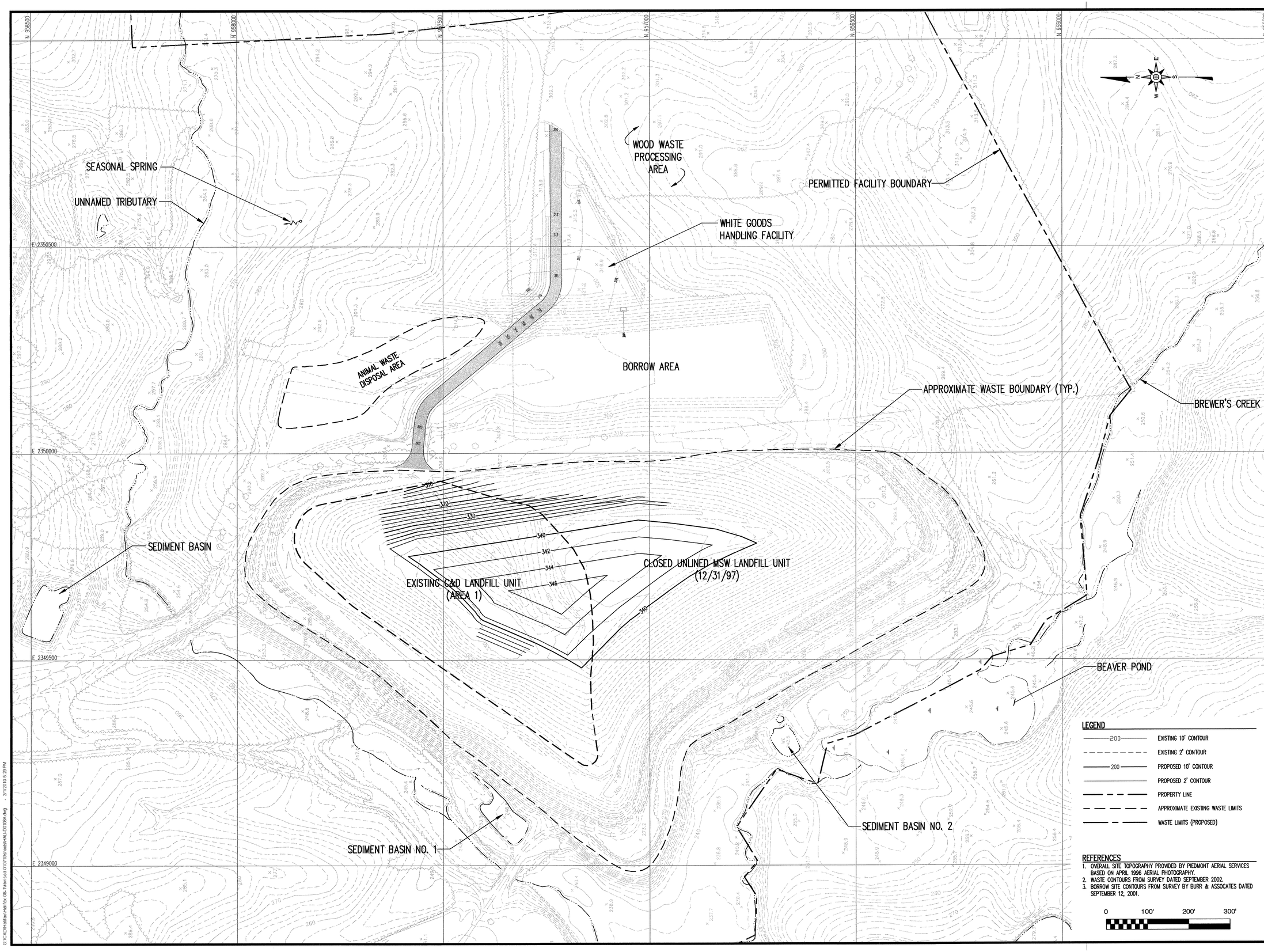

LEGEND

200	EXISTING 10' CONTOUR
	EXISTING 2' CONTOUR
200	PROPOSED 10' CONTOUR
	PROPOSED 2' CONTOUR
	PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
	WASTE LIMITS (PROPOSED)

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON APRIL 1996 AERIAL PHOTOGRAPHY.
2. WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW SITE CONTOURS FROM SURVEY BY BURR & ASSOCATES DATED SEPTEMBER 12, 2001.

0 100' 200' 300'

DATE	NO.	REVISION
1/10	2	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
14 N. Boylan Ave.
Raleigh, N.C. 27603
NC LIC. NO. C-0824 (Engineering)
www.rsgengineers.com
ph: 919-828-0577
fax: 919-828-3899

SEAL

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ENGINEER PIETER K. SCHEER
SEAL 021666
PROFESSIONAL ENGINEER
NORTH CAROLINA
2/2/10

PROJECT TITLE:

HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:

AREA 1 PERMITTED
INTERMEDIATE COVER GRADES

DESIGNED BY: P.K.S	DRAWN BY: C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX 08-1
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: HALI-D0108A	
SHEET NO. 3	DRAWING NO. S2

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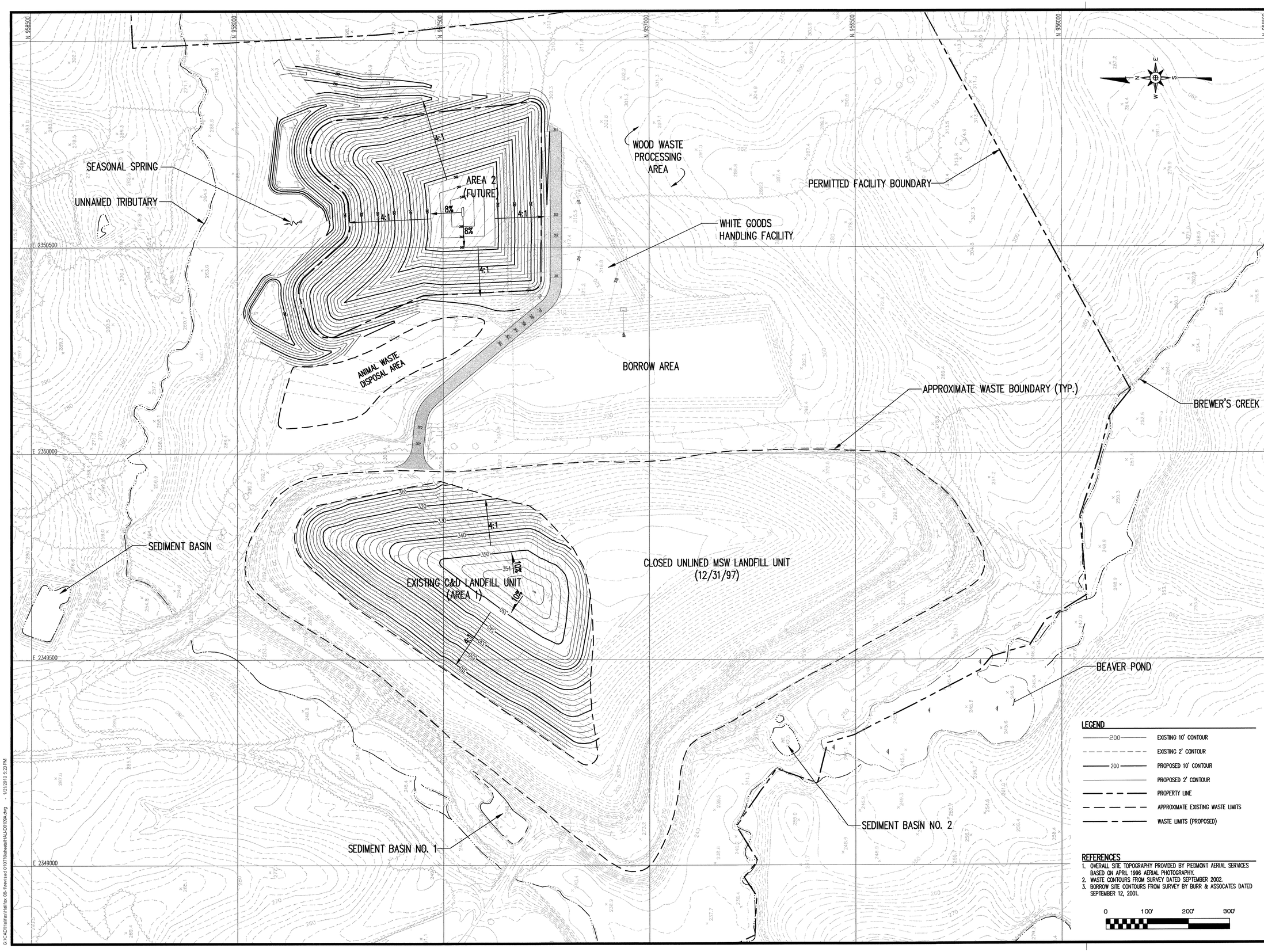

LEGEND

200	EXISTING 10' CONTOUR
	EXISTING 2' CONTOUR
200	PROPOSED 10' CONTOUR
	PROPOSED 2' CONTOUR
	PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
	WASTE LIMITS (PROPOSED)

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON APRIL 1996 AERIAL PHOTOGRAPHY.
2. WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW SITE CONTOURS FROM SURVEY BY BURR & ASSOCATES DATED SEPTEMBER 12, 2001.

0 100' 200' 300'

DATE	NO.	REVISION
1/10	2	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
14 N. Boylan Ave.
Raleigh, N.C. 27603
ph: 919-828-0577
fax: 919-828-3899
www.rsgengineers.com

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021666 PIETER K. SCHEER 2/2/10

PROJECT TITLE:

HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:

C&D LANDFILL
DEVELOPMENT PLAN

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX 08-1
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: HALI-D0109A	
SHEET NO. 4	DRAWING NO. S3

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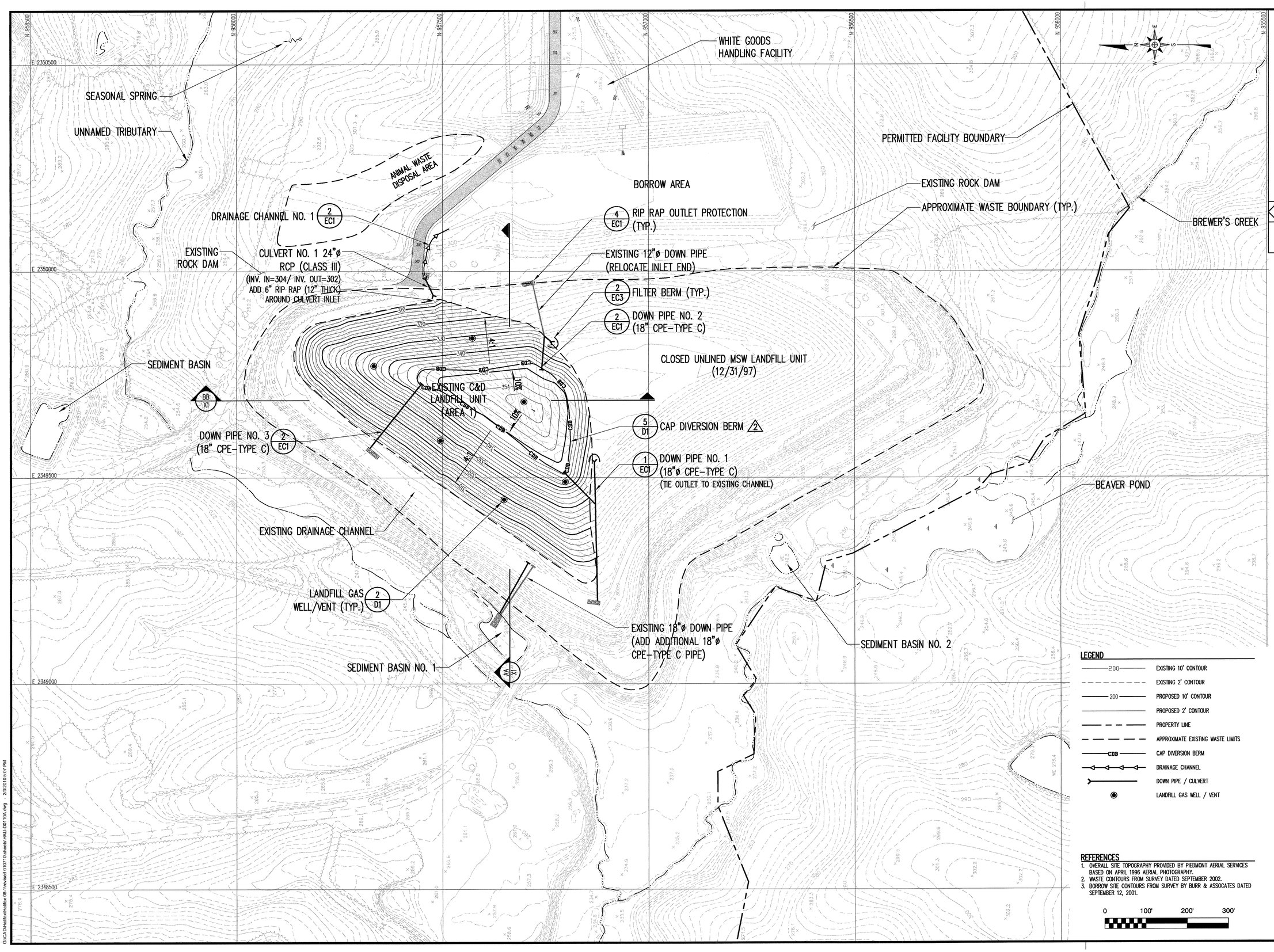

LEGEND

200	EXISTING 10' CONTOUR
	EXISTING 2' CONTOUR
200	PROPOSED 10' CONTOUR
	PROPOSED 2' CONTOUR
	PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
CDB	CAP DIVERSION BERM
	DRAINAGE CHANNEL
	DOWN PIPE / CULVERT
	LANDFILL GAS WELL / VENT

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON APRIL 1996 AERIAL PHOTOGRAPHY.
2. WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW SITE CONTOURS FROM SURVEY BY BURR & ASSOCATES DATED SEPTEMBER 12, 2001.

0 100' 200' 300'

DATE	NO.	REVISION
1/10	2	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
NC LIC. NO. C-0628 (Engineering)
14 N. Boylan Ave.
Raleigh, N.C. 27603
ph: 919-828-0577
fax: 919-828-3899
www.rsgengineers.com

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021666 PIETER K. SCHEER 3/3/10

PROJECT TITLE:

HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:

AREA 1 FINAL COVER
GRADING AND DRAINAGE PLAN

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX 08-1
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: HALI-D0110A	
SHEET NO. 5	DRAWING NO. S4

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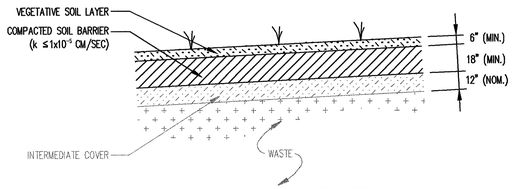
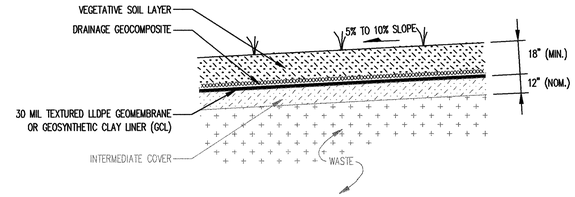
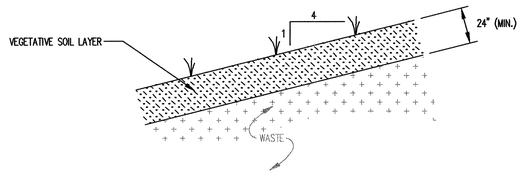


REGULATORY FINAL COVER SYSTEM



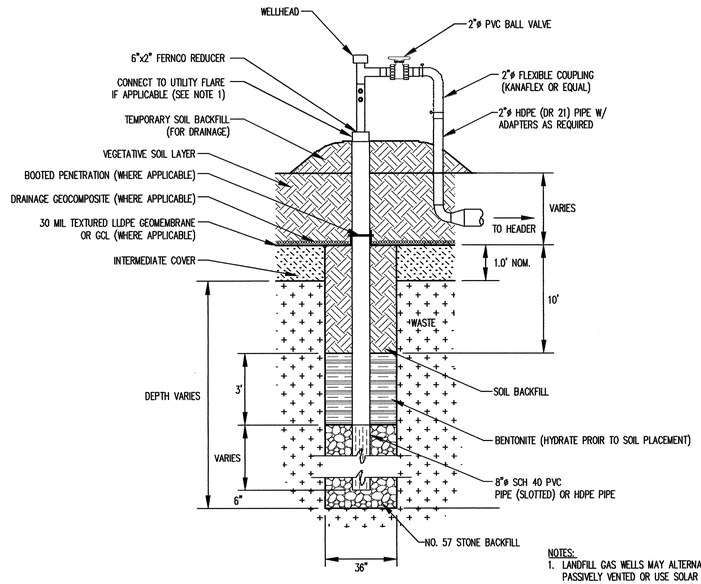
ALTERNATIVE FINAL COVER SYSTEM – TOP SLOPES



ALTERNATIVE FINAL COVER SYSTEM – SIDE SLOPES

FINAL COVER SIDE SLOPE CROSS SECTION

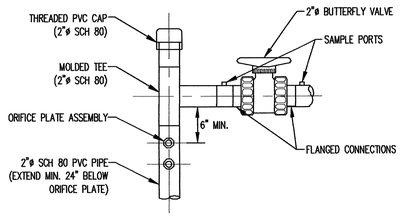
DETAIL 1/D1 (2) — NOT TO SCALE



TYPICAL LANDFILL GAS WELL

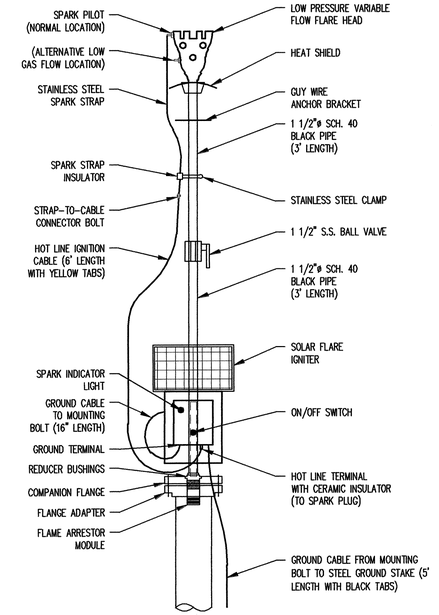
DETAIL 2/D1 — NOT TO SCALE

NOTES:
1. LANDFILL GAS WELLS MAY ALTERNATIVELY BE PASSIVELY VENTED OR USE SOLAR FLARES. SEE DETAIL 4/D1 FOR A TYPICAL UTILITY FLARE.
2. AS AN ALTERNITIVE TO WELLS, GAS COLLECTION TRENCHES MAY BE INSTALLED JUST BELOW THE INTERMEDIATE COVER. TRENCHES SHALL CONSIST OF PERFORATED PIPE BEDDED IN NO. 57 STONE AND WRAPPED IN A TYPE GT-S GEOTEXTILE. TRENCHES SHALL HAVE NOMINAL SIZE OF 6' WIDE x 20' LONG x 2' DEEP.



TYPICAL WELLHEAD

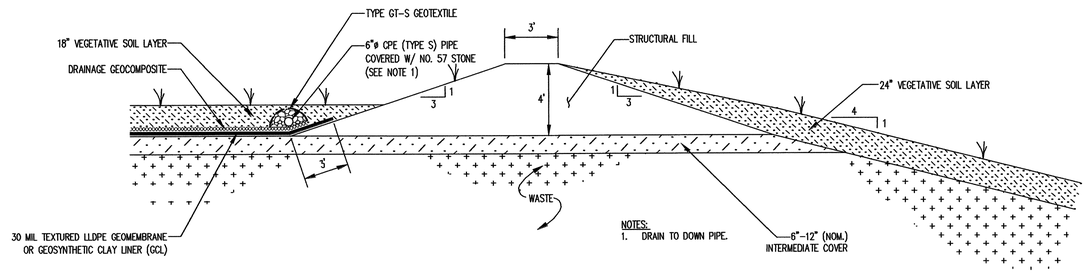
DETAIL 3/D1 — NOT TO SCALE



NOTE:
1. USE LANDFILL TECHNOLOGIES, INC. CF-5 SOLAR FLARE OR OTHER APPROVED EQUAL.

LFG UTILITY FLARE

DETAIL 4/D1 — NOT TO SCALE



NOTES:
1. DRAIN TO DOWN PIPE.

CAP DIVERSION BERM

DETAIL 5/D1 (2) — NOT TO SCALE

NO.	DATE	REVISION
1	1/10	EDITS PER DWM COMMENTS
2	8/09	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
8000 Regency Parkway, Suite 600
Cary, North Carolina 27518
14 N. Boylan Ave.
Raleigh, N.C. 27603
ph: 919-828-0577
fax: 919-828-3899
www.rsgengineers.com

SEAL

SEAL
PETER K. SMITH
SEAL 021686
ENGINEER
PROFESSIONAL
NORTH CAROLINA
2/10

PROJECT TITLE:
HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:
FINAL COVER
LANDFILL GAS MANAGEMENT
DETAILS

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY:	PROJECT NO.:
PKS	HALIFAX.081
SCALE:	DATE:
AS SHOWN	JUNE 2009
FILE NAME:	HALI-D0111B
SHEET NO.	DRAWING NO.
6	D1

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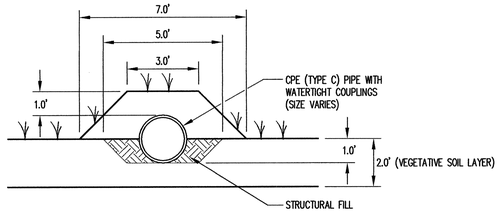
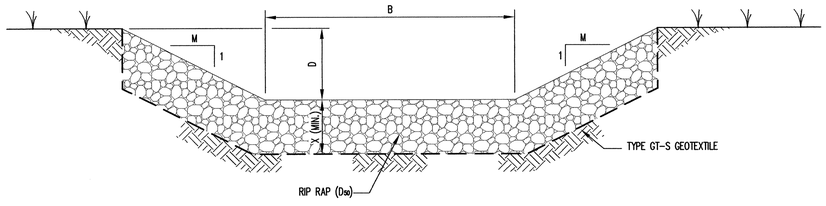


DOWN PIPE ON SLOPE

DETAIL 1 / EC1
NOT TO SCALE

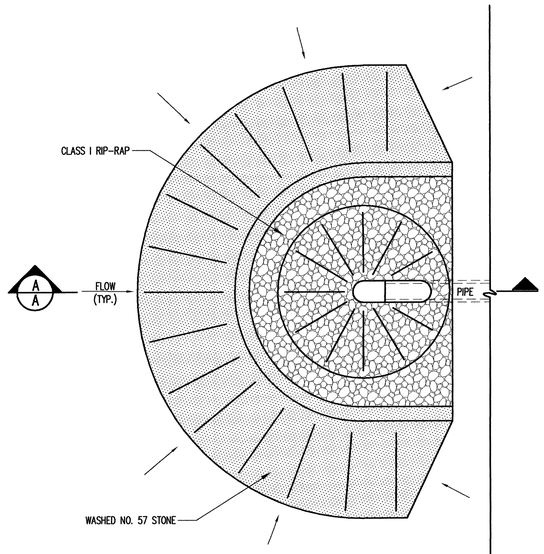
DRAINAGE CHANNEL SCHEDULE						
DRAINAGE CHANNEL NO.	LINING	B (FEET)	D (FEET)	M	D_{50} (INCHES)	X (FEET)
1	RIP RAP	6	2	3	6	1.0



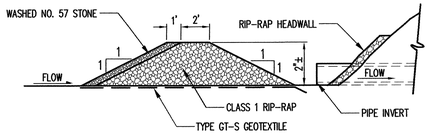
RIP RAP LINED CHANNELS

DRAINAGE CHANNEL DETAIL

DETAIL 2 / EC1
NOT TO SCALE



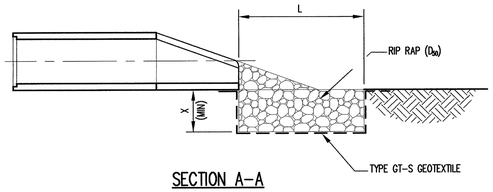
PLAN



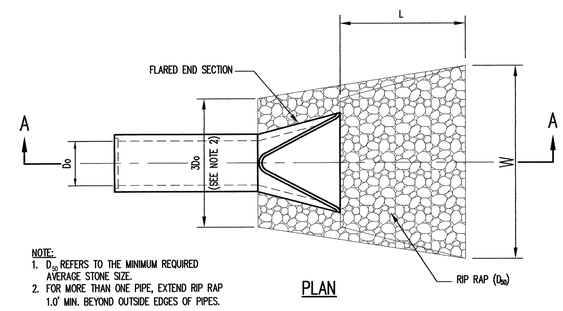
SECTION A-A

FILTER BERM

DETAIL 3 / EC1
NOT TO SCALE



SECTION A-A



NOTE:
1. D_{50} REFERS TO THE MINIMUM REQUIRED AVERAGE STONE SIZE.
2. FOR MORE THAN ONE PIPE, EXTEND RIP RAP 1.0' MIN. BEYOND OUTSIDE EDGES OF PIPES.

PLAN

RIP RAP OUTLET PROTECTION (OUTLET TO FLAT AREA)

DETAIL 4 / EC1
NOT TO SCALE

RIP RAP OUTLET PROTECTION SCHEDULE					
PIPE	D_0 (INCHES)	L (FEET)	W (FEET)	D_{50} (INCHES)	X (FEET)
EXISTING DOWN PIPE	18 (x2)	34	16	6	1.0
DOWN PIPE NO. 1	18	10	(SEE NOTE 1)	6	1.0
DOWN PIPE NO. 2	18	10	(SEE NOTE 1)	6	1.0
DOWN PIPE NO. 3	18	10	(SEE NOTE 1)	6	1.0
CULVERT NO. 1	24	16	18	9	1.5
NOTE: 1. EXTEND RIP RAP APRON ACROSS ENTIRE CHANNEL WIDTH.					

DATE	NO.	REVISION
1/10	2	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
NO LIC. NO C-0208 (Engineering)
14 N. Boylan Ave.
Raleigh, N.C. 27603
www.rsgengineers.com
ph: 919-828-0577
fax: 919-828-3899

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INDIRA CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PIETER K. SCHEER 2/3/10

PROJECT TITLE:
HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:
EROSION AND SEDIMENTATION CONTROL DETAILS (SHEET 1 OF 2)

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX 08-1
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: HALI-D0112A	
SHEET NO. 7	DRAWING NO. EC1

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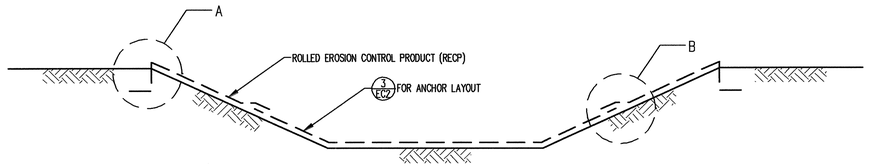
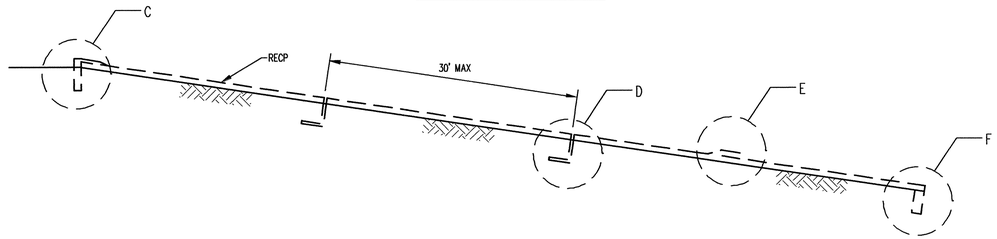
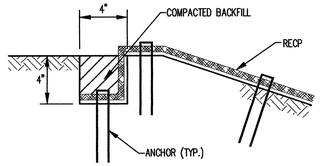


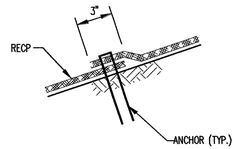
TYPICAL CHANNEL CROSS SECTION



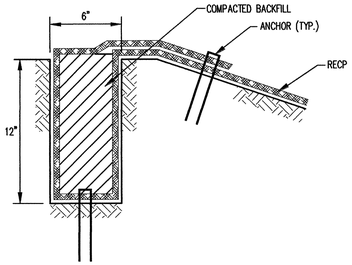
TYPICAL CHANNEL PROFILE



A. LONGITUDINAL ANCHOR TRENCH

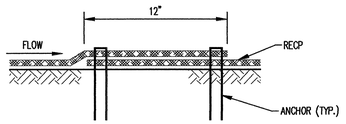


B. OVERLAP AT ADJACENT EDGES

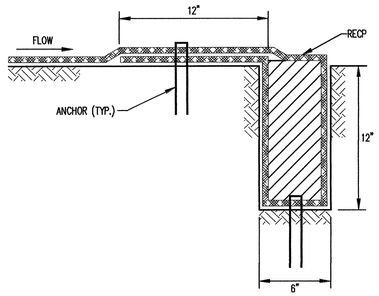


C. UPSTREAM TERMINAL ANCHOR TRENCH

D. INTERMITTENT CHECK SLOT



E. OVERLAP AT ROLL ENDS



F. DOWNSTREAM TERMINAL ANCHOR TRENCH

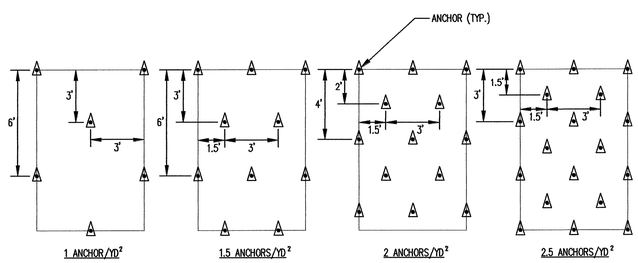
NOTES:

1. PLACE ANCHORS AT ANCHOR TRENCHES, OVERLAPS, AND CHECK SLOTS ON 1 FOOT CENTERS. IF APPLICABLE, STAGGER ANCHOR SPACING BETWEEN MULTIPLE ROWS OF ANCHORS.

INSTALLATION OF ROLLED EROSION CONTROL PRODUCTS (CHANNELS)

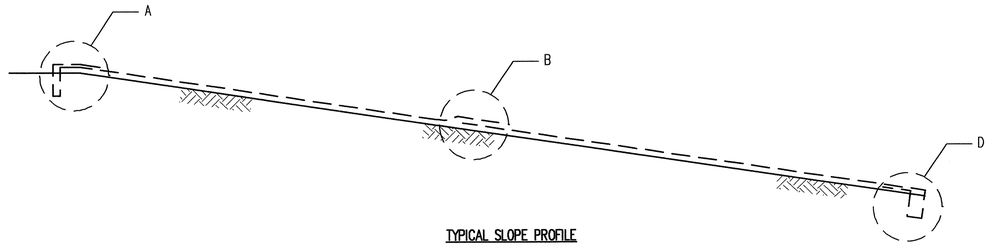
DETAIL 1 EC2 — NOT TO SCALE

ANCHOR SPACING SCHEDULE	
LOCATION	REQUIRED ANCHOR SPACING (ANCHORS/YD²)
ALL CHANNELS	2.5
1.5H:1V SLOPES	2.0
2H:1V SLOPES	2.0
2.5H:1V SLOPES	1.5
3H:1V SLOPES	1.5
3.5H:1V SLOPES	1.0
4H:1V SLOPES	1.0

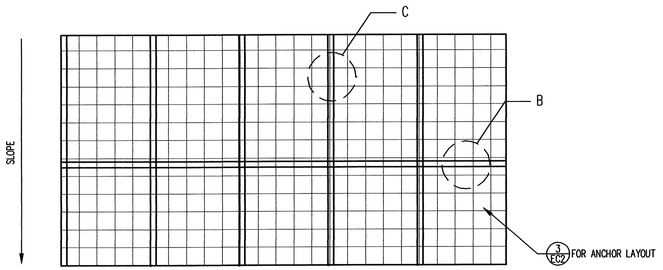


ANCHOR LAYOUT

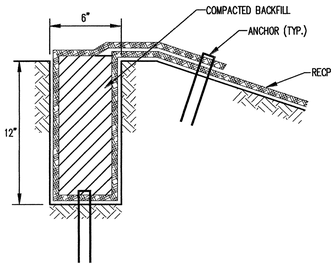
DETAIL 3 EC2 — NOT TO SCALE



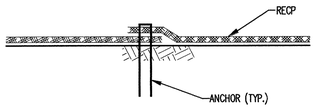
TYPICAL SLOPE PROFILE



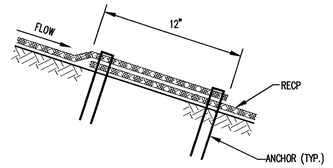
TYPICAL SLOPE PLAN VIEW



A. UPSLOPE TERMINAL ANCHOR TRENCH



C. OVERLAP AT ADJACENT EDGES



B. OVERLAP AT ROLL ENDS

D. DOWNSLOPE TERMINAL ANCHOR TRENCH

NOTE:

1. PLACE ANCHORS AT ANCHOR TRENCHES, OVERLAPS, AND CHECK SLOTS ON 1 FOOT CENTERS. IF APPLICABLE, STAGGER ANCHOR SPACING BETWEEN MULTIPLE ROWS OF ANCHORS.

INSTALLATION OF ROLLED EROSION CONTROL PRODUCTS (SLOPES)

DETAIL 2 EC2 — NOT TO SCALE

NO.	DATE	REVISION
2	1/10	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
ARCHITECTURE ENGINEERING
14 N. Boylan Ave. Raleigh, N.C. 27603
ph: 919-828-0577 fax: 919-828-3899
www.rsgengineers.com

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 21088 PIETER K. SWART

PROJECT TITLE:
HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:
EROSION AND SEDIMENTATION
ECONTROL DETAILS
(SHEET 2 OF 2)

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY:	PROJECT NO.:
PKS	HALIFAX.081
SCALE:	DATE:
AS SHOWN	JUNE 2008
FILE NAME	
HALI-D0113A	
SHEET NO.	DRAWING NO.
8	EC2

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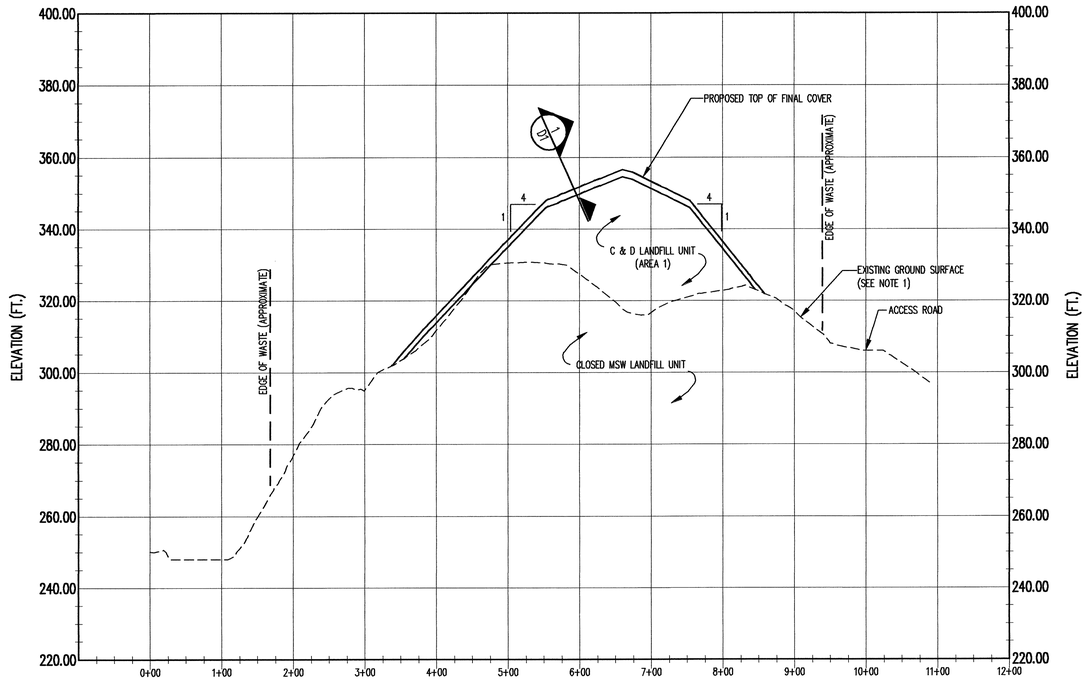

SECTION AA / X1
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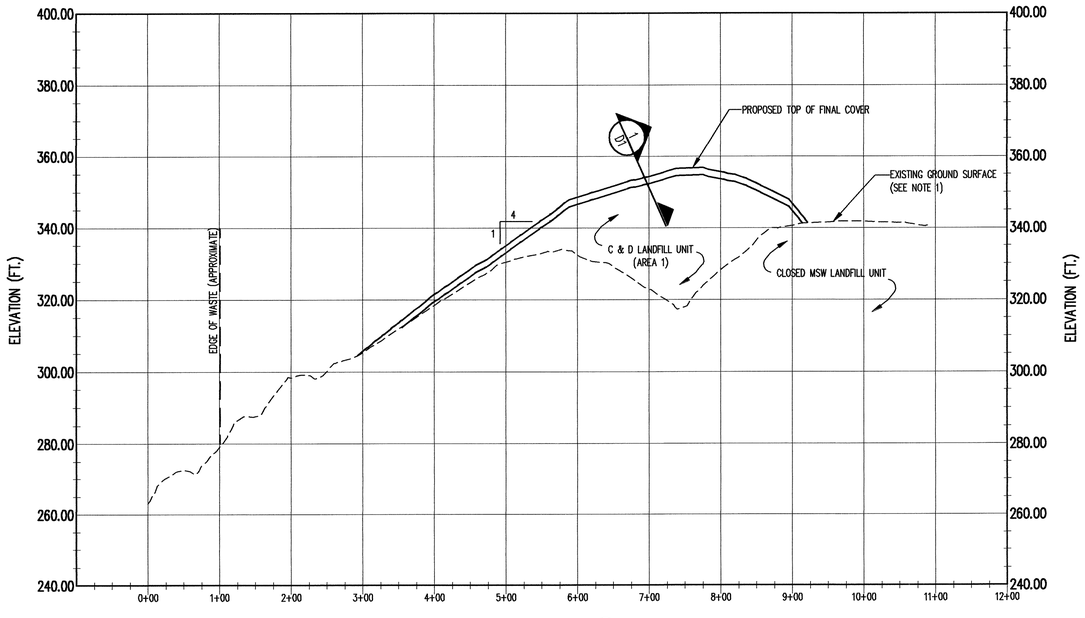


SECTION BB / X1
NOT TO SCALE

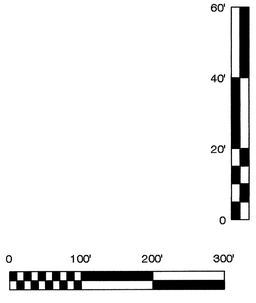
LEGEND

- - - - - - - - EXISTING GROUND (SEE REFERENCE 1)

———————— PROPOSED FINAL COVER GRADES

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON APRIL 1996 AERIAL PHOTOGRAPHY.
2. WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW SITE CONTOURS FROM SURVEY BY BURR & ASSOCATES DATED SEPTEMBER 12, 2001.
4. REFER TO SITE PLAN DRAWINGS FOR CROSS SECTION LOCATIONS.



DATE	NO.	REVISION
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RICHARDSON SMITH GARDNER & ASSOCIATES
14 N. Boylan Ave.
Raleigh, N.C. 27603
NO LIC. NO. C-0231 (Engineering)
www.regengineers.com
ph: 919-828-0577
fax: 919-828-3899

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PROJECT TITLE:
HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:
ENGEINEERING CROSS SECTIONS

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX 081
SCALE: AS SHOWN	DATE: JUNE 2009
FILE NAME: HALI-D0115A	
SHEET NO. 9	DRAWING NO. X1

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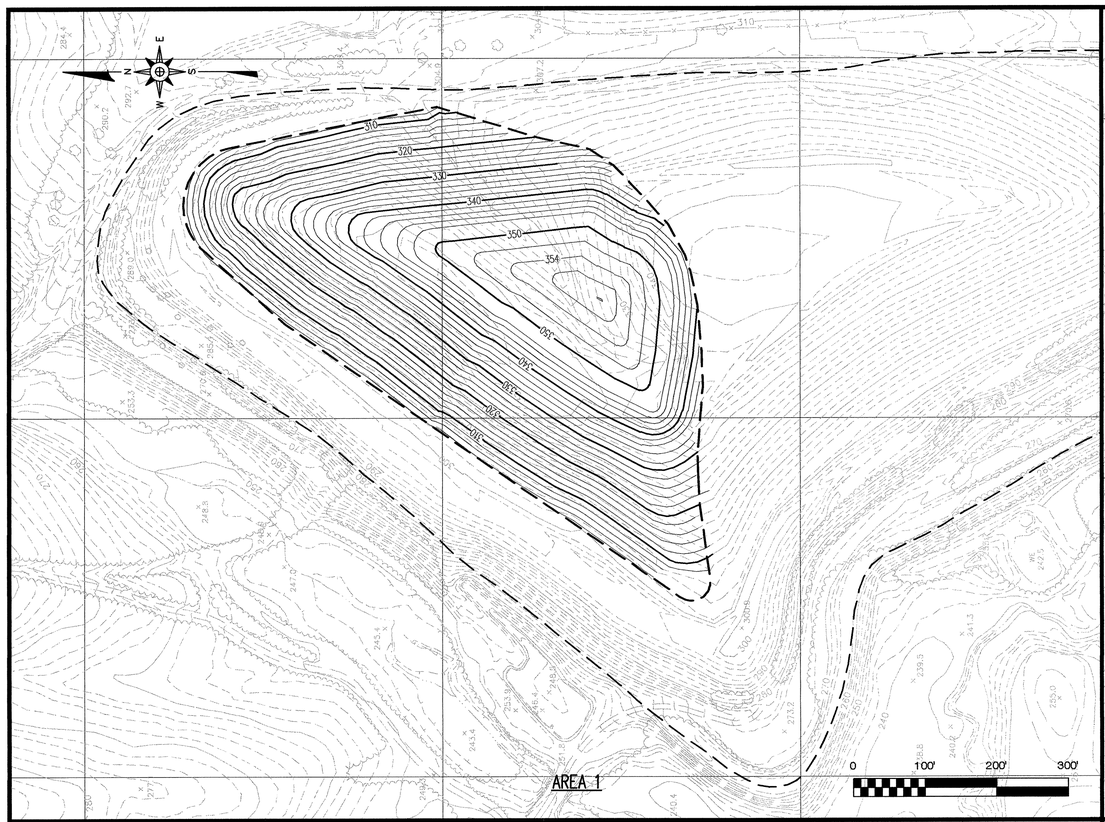

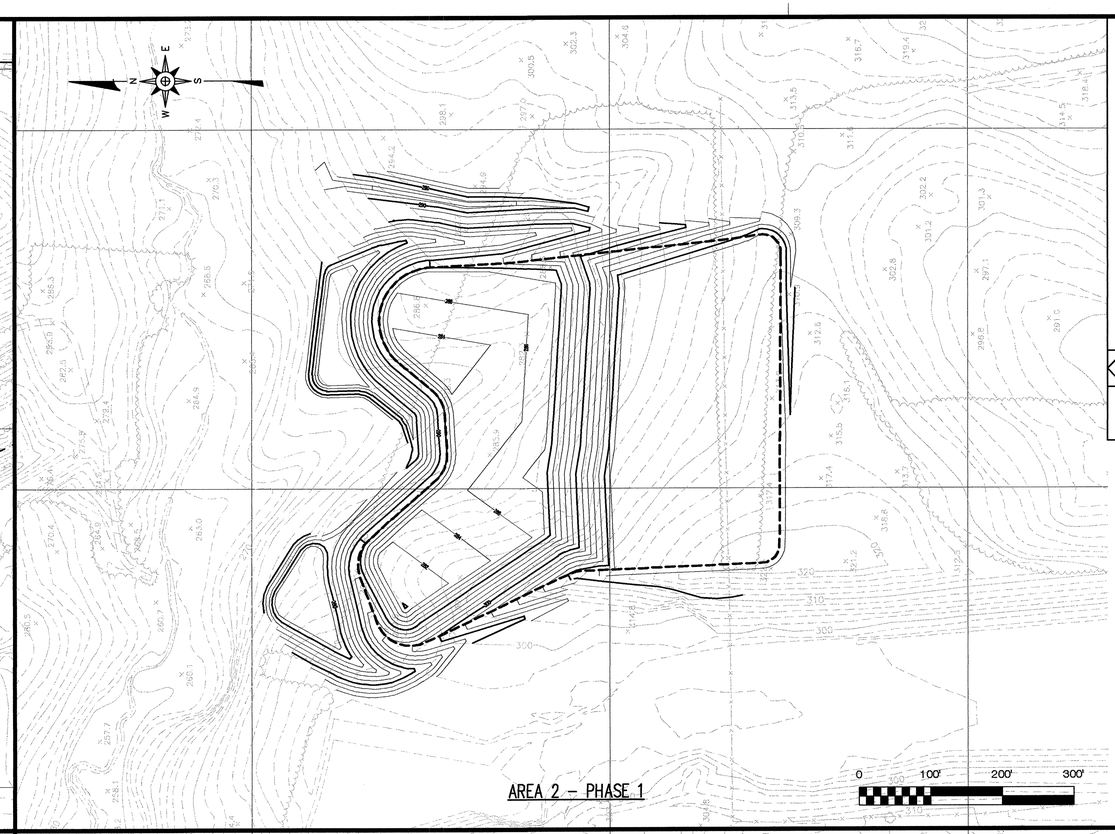

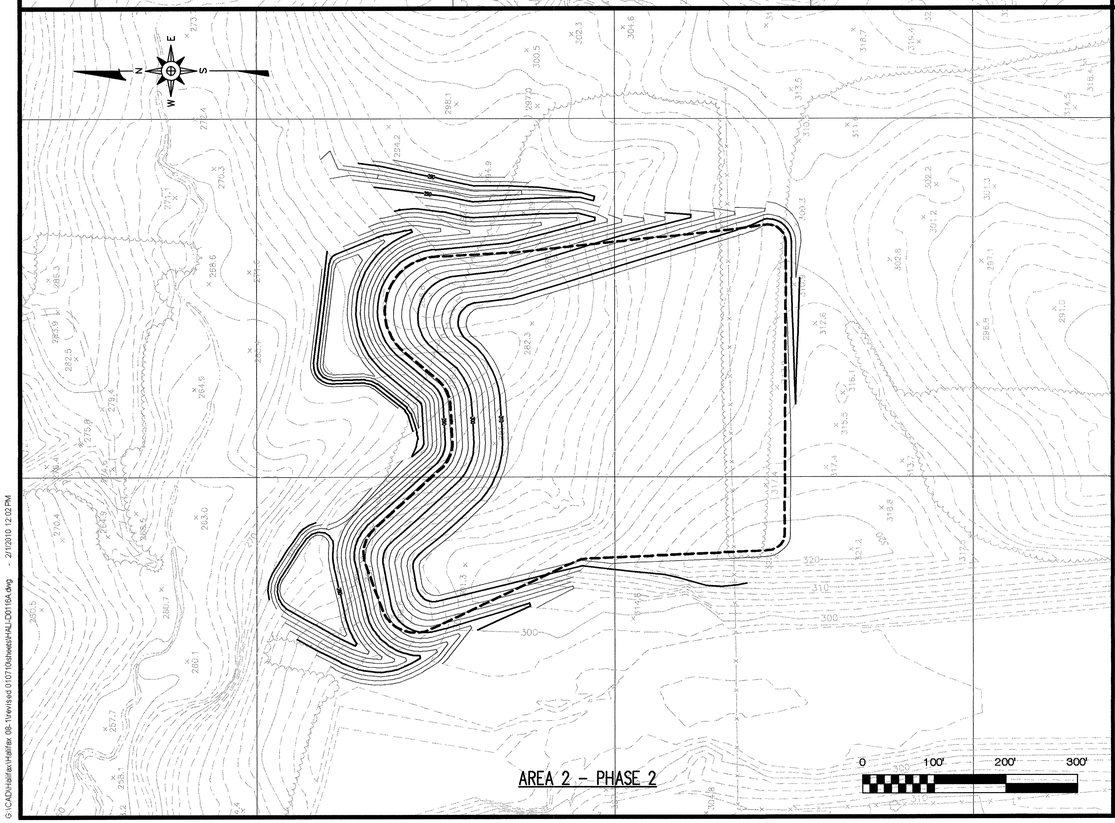

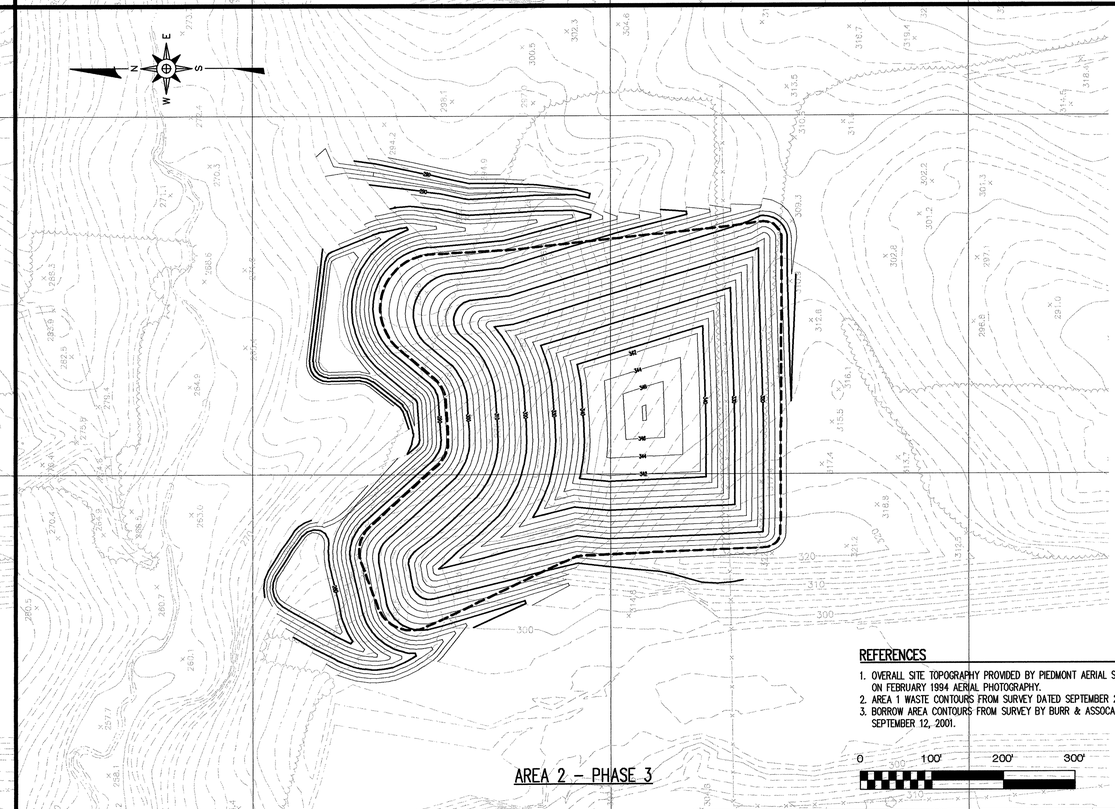

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON FEBRUARY 1994 AERIAL PHOTOGRAPHY.
2. AREA 1 WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW AREA CONTOURS FROM SURVEY BY BURR & ASSOCATES DATED SEPTEMBER 12, 2001.

DATE	NO.	REVISION
1/10	2	EDITS PER DWM COMMENTS

RICHARDSON SMITH GARDNER & ASSOCIATES
14 N. Boylan Ave.
Raleigh, N.C. 27603
NC LIC. NO. C-0828 (Engineering)
www.rsgengineers.com
ph: 919-828-0577
fax: 919-828-3899

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021666 PIETER K. SCHEER 2/2/10

PROJECT TITLE:

HALIFAX COUNTY
C&D LANDFILL - AREA 1
CONTINUED OPERATIONS
PERMIT DRAWINGS

DRAWING TITLE:

PHASING PLAN

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: PKS	PROJECT NO.: HALIFAX 081
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: HALI-D0116A	
SHEET NO. 10	DRAWING NO. P1

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