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Facility and Engineering Plan

Halifax County C&D Landfill - Area 2
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

December 2012

NC LIC. NO. C-0828 (ENGINEERING)

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Halifax County C&D Landfill - Area 2
Halifax County, North Carolina

Facility and Engineering Plan

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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.

As Area 1 nears capacity, the County plans to develop the Area 2 disposal unit at the facility (see **Drawings S2 and S3**). Based on current projections, Area 1 is expected to remain in operation through 2013. Once Area 1 has reached capacity, the County will need to begin disposal in the Area 2 landfill unit. This plan presents information describing the completion of operations of the Area 1 landfill unit and the development of the Area 2 landfill unit.

It is the intent of Halifax County to proceed with the construction of Area 2 in mid 2013. The excavation generated by construction of Area 2 will be used to begin the closure 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:

- Scale and scale house;
- Administrative office and maintenance building;
- MSW Transfer Station (under construction);
- Area 1 C&D Landfill Unit (vertical expansion over closed unlined MSW unit);
- Area 2 C&D Landfill Unit (Proposed);
- Ash Monofill (Cells 1 & 2 Active);

- 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 Rates and Estimated Variances

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 has recently averaged about 150,000 tons per year (average of 536 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. For purposes of life expectancy calculations for the C&D landfill units, annual disposal rates of 5,500 tons and 7,500 tons were assumed for Areas 1 and 2, respectively.

2.4 Service Area

The landfill facility currently serves Halifax County.

2.5 Procedures for Waste Segregation

A brief description of planned procedures for waste segregation at the landfill is as follows.

Wastes are segregated at the scale. 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 on-site MSW transfer station (after 6/30/13).

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.

Refer also to the facility Operations Manual (**Attachment D**) for more information.

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 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 P1 (Phasing 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, then transition at flatter slopes (5 to 10%) to the peak elevations. Top elevations will be 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**. As noted in **Section 2.3**, life expectancies were calculated based on a disposal rate of 5,500 tons per year for Area 1 and 7,500 tons per year for Area 2.

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 1,200 pounds pcy (0.6 tons/cy). The assumed periodic cover ratio is typical for C&D landfills.

Note that changes in landfill operations (i.e. changes in compaction equipment/methods) may affect the values assumed above and, thus, alter the life of the various landfill units.

4.0 AVAILABLE SOIL RESOURCES AND REQUIRED SOIL QUANTITITES

4.1 Earthwork Quantities

The soils required to construct and operate the existing and planned C&D landfill units will be removed from on-site borrow sources. The soils removed during excavation of landfill units may be used for structural fill, periodic cover, final cover, and general fill. These excavation (cut) and structural fill (fill) volumes are shown in **Table 2**.

4.2 Periodic Cover

Assuming the previously mentioned periodic cover ratio, the required in-place volume for use as periodic cover during operations of each landfill unit is shown in **Table 2**.

4.3 Compacted Soil Barrier

On the basis of the 1.5-foot thick compacted soil barrier required for the Area 2 final cover, the in place volume required is shown in **Table 2**.

4.4 Vegetative Soil Layer

On the basis of an average 2-foot thick vegetative soil layer for the Area 1 final cover and 1.5-foot thick vegetative soil layer for the Area 2 final cover, the in place volume required for each landfill unit is shown in **Table 2**.

4.5 Soil Summary

The above soil quantities are summarized in **Table 2**. On-site borrow sources are anticipated to have an adequate supply of soil to meet these needs.

5.0 FACILITY DESIGN CRITERIA

Existing and proposed C&D landfill units were/will be constructed in accordance with Section .0540 of the North Carolina Administrative Code, Title 15A, Chapter 13, Subchapter 13B including the following requirements.

5.1 Horizontal Separation Requirements

The horizontal separation requirement between the disposal boundary (edge of waste) and the property lines is a minimum of 200 feet; the minimum buffer between private residences and wells and the disposal boundary is 500 feet; and the minimum buffer between any surface water (stream, river, creek) and the disposal boundary is 50 feet. The proposed design satisfies all buffer requirements.

5.2 Vertical Separation Requirements

The post-settlement bottom elevation of the liner system will meet the minimum requirement of four feet above the seasonal high groundwater table and bedrock.

6.0 CONTAINMENT AND ENVIRONMENTAL CONTROL SYSTEMS

The following systems and elements are the basic containment and environmental controls for the Area 2 C&D landfill unit. Technical specifications and construction quality assurance requirements can be found in Attachments B and C, respectively.

6.1 Landfill Subgrade and Perimeter Berms

The landfill subgrade elevations will be achieved by excavation or placement of compacted structural fill (embankment). During excavation, a determination of unsuitable soils (i.e. soils which are too soft, wet, or organic) will be made. Where unsuitable soils are found, the soils will be undercut and backfilled with structural fill.

In addition to providing the liner foundation in fill areas, structural fill will be used for berm and roadway construction. Structural fill will consist of on site soils removed during excavation of the landfill units or imported borrow soils, except that no OL or OH soils will be allowed.

Per State regulations, the upper 2 feet of the landfill subgrade must consist of SC, SM, ML, CL, MH, or CH soils (per Unified Soil Classifications System). Verification of this requirement will be performed during construction.

6.2 Final Cover System

The final cover system for Area 2 will consist of the following components (top-down):

Regulatory Final Cover System (.0543 (c) (1)):

- an 18-inch thick vegetative soil layer; and
- an 18-inch thick soil liner with a hydraulic conductivity of no more than 1 x 10^{-5} cm/sec ("compacted soil barrier").

6.3 Erosion and Sedimentation Control

Erosion and sedimentation control devices/measures will be designed and maintained to manage the run-off generated by the 25-year 24-hour storm event and conform to the requirements of the North Carolina Sedimentation Pollution Control Law (15A, NCAC, 4).

A detailed discussion of site erosion and sedimentation control can be found in the Erosion and Sedimentation Control Plan (Attachment F).

6.4 Landfill Gas Control

The landfill gas (LFG) control system for Area 2 will consist of wells and/or vents placed within the waste to capture and passively vent the gas. Wells and/or vents will be placed in conjunction with the final cover system.

6.5 Access and Roadways

The Halifax County Landfill facility is accessed from Liles Road. A scale and scale house are located near this entrance. Drawing S1 (Existing Conditions) shows this infrastructure.

All-weather access to active areas as well as areas under intermediate cover will be provided. Access ramps into the landfill units will be provided where necessary.

7.0 SLOPE STABILITY AND SETTLEMENT

An evaluation of the slope stability of the overall waste mass and perimeter berm as well as an evaluation of foundation settlement are addressed in Appendix A. These analyses indicate that the proposed Area 2 landfill configuration will be stable and that maximum settlement will be negligible (less than 3 inches).

Table 1 Total Operating 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 25, 2012)	6.5	94,025	84,623 CY 72,561 Tons	-----
Area 1 (Remaining)	-----	37,242	14,462 CY 8,785 Tons	1.6 (See Note 2)
Area 2 - Phase 1	3.3	73,129	65,816 CY 39,490 Tons	5.3 (See Note 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	313,897 CY 210,234 Tons	18.8

Notes:

1. The net capacity is based on an assumed 10% periodic cover soil ratio and waste density of 0.6 tons/CY.
2. Area 1 life expectancy is based on an assumed average disposal rate of 5,500 tons/year and is projected from May 25, 2012.
3. Area 2 life expectancy values are 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	(1,627)	(7,313)	(8,331)	(8,224)	(25,495)
Compacted Soil Barrier	-----	-----	(3,630)	(10,164)	(13,794)
Vegetative Soil Layer	(20,973)	-----	(3,630)	(10,164)	(34,767)
Totals:	(22,600)	65,188	(15,591)	(28,552)	(1,555)

Notes:

1. Area 1 volumes estimated from May 25, 2012.

Appendix A

Landfill Design Calculations

Facility and Engineering Plan
Halifax County C&D Landfill - Area 2
Halifax County, North Carolina

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Facility and Engineering Plan
Appendix A: Landfill Design Calculations

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1.0 Quantity Calculations
- Capacity Evaluation (Density & Life Calcs.)
- Earthwork Quantities

2.0 Slope Stability Evaluation

3.0 Foundation Settlement Evaluation

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PROJECT **Halifax County C&D Landfill** SHEET 1 OF 9 DATE 12/4/2012

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SUBJECT **Capacity Evaluation (Density & Life)** JOB # HALIFAX-12-1 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 evalution 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.

PROJECT	**Halifax County Landfill - C&D - Area 1**	SHEET	2/9
		JOB #	HALIFAX-12-1
SUBJECT	**Capacity Evaluation - Filling Rate & Density Calculations**	DATE	12/4/2012
		COMPUTED BY	PKS
		CHECKED BY	

Density and Filling Rate Calculations:

Start Date	Period of Interest End Date	Total Time (years)	Volume Filled (cy)	Quantity of Waste Disposed (tons)	Waste Filling Rate* (lbs/cy)	Periodic Cover Assumed %	Periodic Cover Volume (cy)	Waste Volume (cy)	Waste Density** (lbs/cy)
5/1/2008	7/13/2010	2.20	14,535	10,418	**1,434**	10	1,454	13,082	**1,593**
7/14/2010	5/27/2011	0.87	5,258	3,022	**1,149**	10	526	4,732	**1,277**
5/28/2011	5/25/2012	0.99	11,306	6,510	**1,152**	10	1,131	10,175	**1,280**
	Totals:	**4.06**	**31,099**	**19,950**			**3,110**	**27,989**	**1,426**

Avg. Waste Density = 1,426 lbs/cy

Notes:

*Waste Filling Rate = (Tons of Waste Disposed)/(Volume Filled).

**Waste Density = (Tons of Waste Disposed)/(Volume Filled - Volume of Periodic Cover).

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PROJECT	**Halifax County C&D Landfill**	SHEET	3/9
		JOB #	HALIFAX-12-1
SUBJECT	**Capacity Evaluation - Area 1**	DATE	12/4/2012
		COMPUTED BY	PKS
		CHECKED BY	

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,200	(From Filling Rate and Density Calcs.) (Conservative)
Waste Density (tcy) =	0.60	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) =	37,242	(Existing to Top of Final Cover)
	(= Gross Capacity)	

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	6.5	
2 feet (Avg.)	Vegetative Soil Layer =	(20,973)	cy
	Sum =	(20,973)	cy
	Volume of Waste and Periodic Cover (cy) =	16,269	
	Volume of Periodic Cover (cy) =	(1,627)	
	Net (Waste) Capacity (cy) =	14,642	
	Net (Waste) Capacity (tons) =	8,785	

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2012.4	2013	3,300	3,300	5,485	
2013	2013	0	3,300	5,485	Based on 5,500 Tons per Year
2013	2014	5,485	8,785	0	

Landfill Life Expectancy (years) = 1.6 January 2014

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PROJECT	**Halifax County C&D Landfill**	SHEET	4/9
		JOB #	HALIFAX-12-1
SUBJECT	**Capacity Evaluation - Area 2 - Phase 1**	DATE	12/4/2012
		COMPUTED BY	PKS
		CHECKED BY	

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 Fill Grades)
	(= Gross Capacity)	

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	0	
1.5 feet	Compacted Soil Barrier =	0	cy
1.5 feet	Vegetative Soil Layer =	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
2014	2019.3	39,490	39,490	(0)

Landfill Life Expectancy (years) = 5.3 Based on 7,500 Tons per Year

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PROJECT	**Halifax County C&D Landfill**	SHEET	5/9
		JOB #	HALIFAX-12-1
SUBJECT	**Capacity Evaluation - Area 2 - Phase 2**	DATE	12/4/2012
		COMPUTED BY	PKS
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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 Fill Grades)
	(= Gross Capacity)	

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	1.5	
1.5 feet	Compacted Soil Barrier =	(3,630)	cy
1.5 feet	Vegetative Soil Layer =	(3,630)	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
2019.3	2025.3	44,988	44,988	(0)

Landfill Life Expectancy (years) = 6.0 Based on 7,500 Tons per Year

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PROJECT	**Halifax County C&D Landfill**	SHEET	6/9
		JOB #	HALIFAX-12-1
SUBJECT	**Capacity Evaluation - Area 2 - Phase 3**	DATE	12/4/2012
		COMPUTED BY	PKS
		CHECKED BY	

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 Fill Grades)
	(= Gross Capacity)	

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	4.2	
1.5 feet	Compacted Soil Barrier =	(10,164)	cy
1.5 feet	Vegetative Soil Layer =	(10,164)	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
2025.3	2031.2	44,410	44,410	(0)

Landfill Life Expectancy (years) = 5.9 Based on 7,500 Tons per Year

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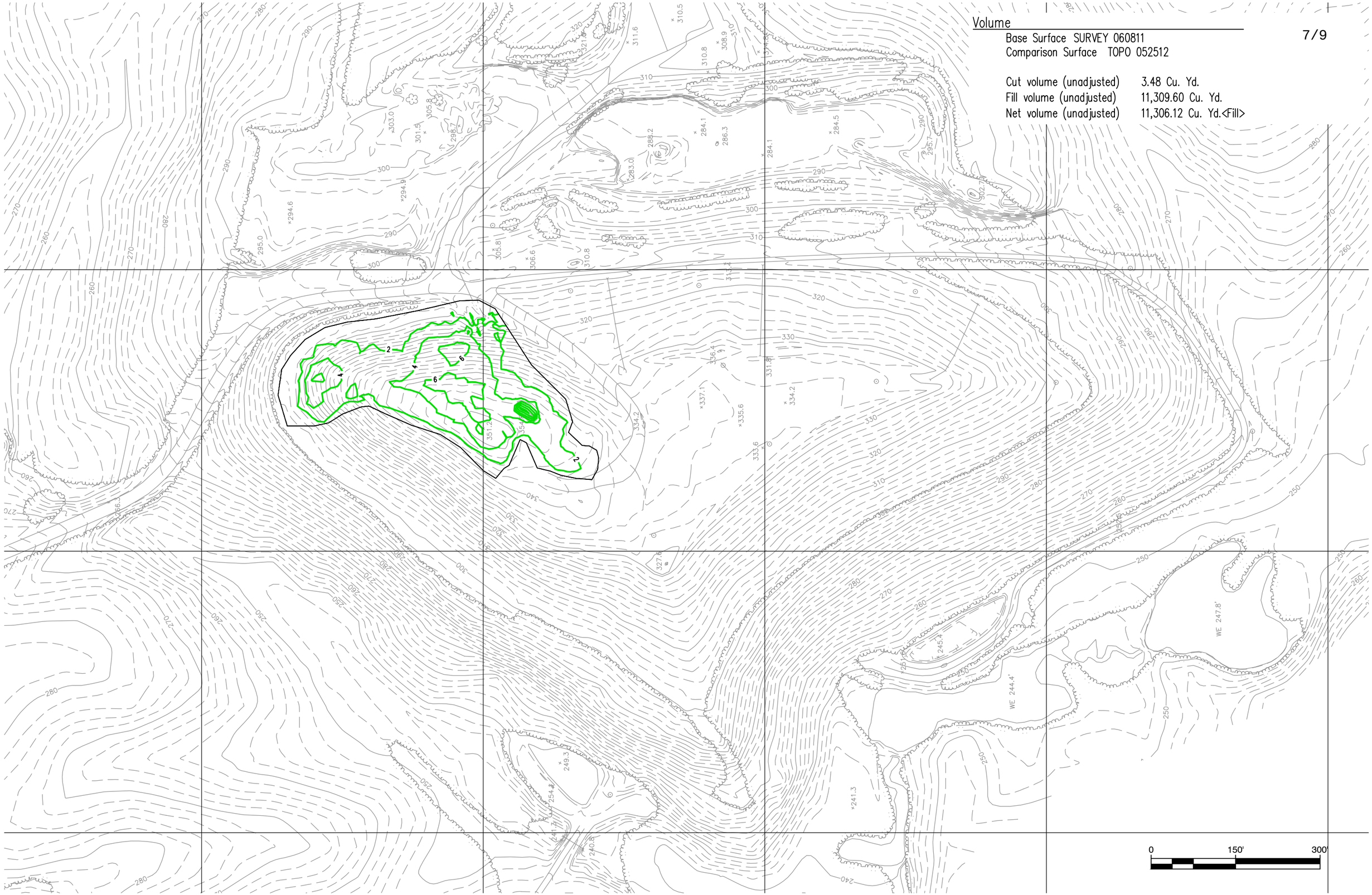
Volume

Base Surface SURVEY 060811
Comparison Surface TOPO 052512

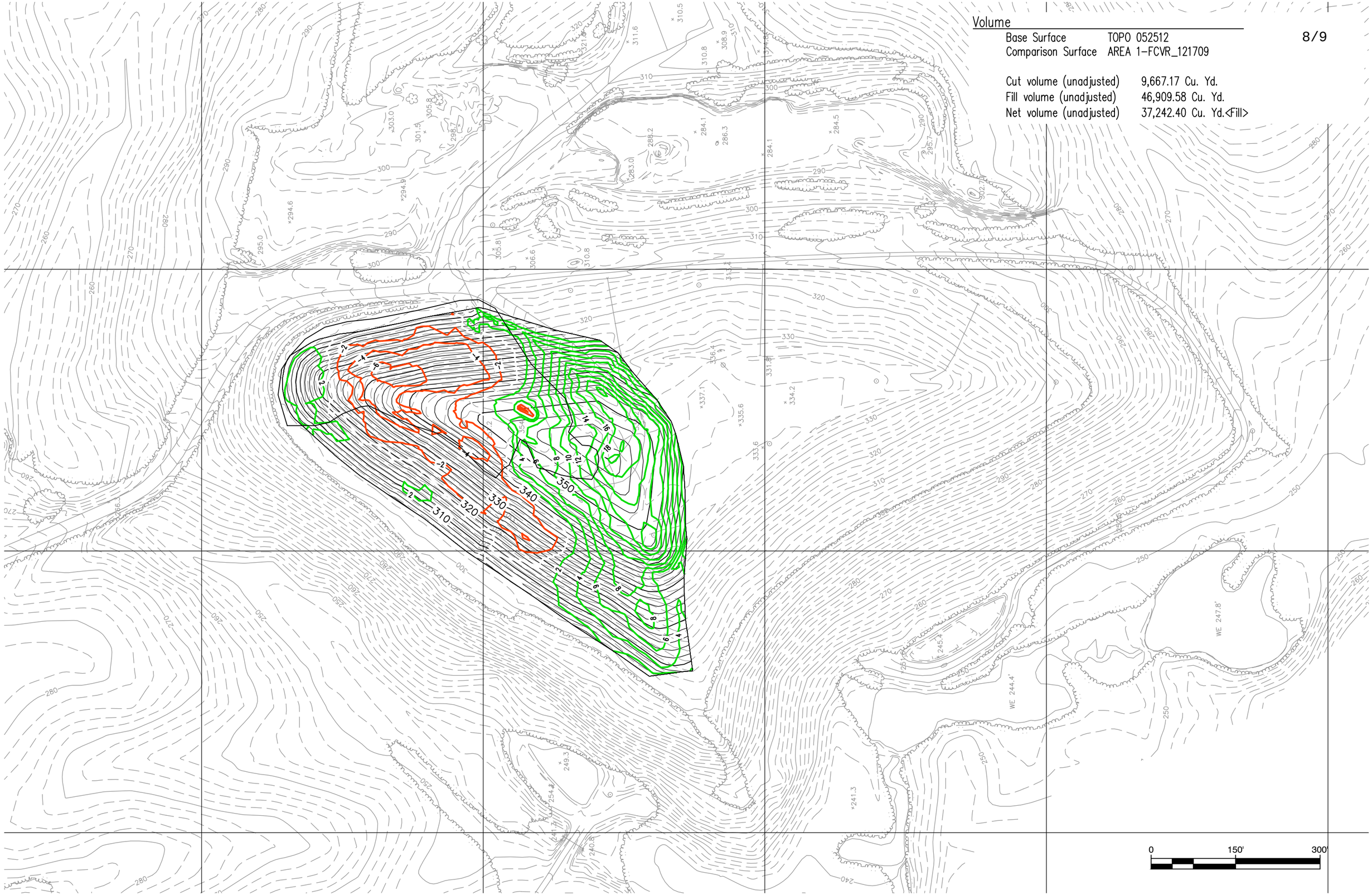
Cut volume (unadjusted)	3.48 Cu. Yd.
Fill volume (unadjusted)	11,309.60 Cu. Yd.
Net volume (unadjusted)	11,306.12 Cu. Yd.<Fill>



Volume

Base Surface	TOPO 052512
Comparison Surface	AREA 1-FCVR_121709

Cut volume (unadjusted)	9,667.17 Cu. Yd.
Fill volume (unadjusted)	46,909.58 Cu. Yd.
Net volume (unadjusted)	37,242.40 Cu. Yd.<Fill>



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>	
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>	

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PROJECT **Halifax County C&D Landfill** SHEET 1 OF 3 DATE 12/12/2012

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SUBJECT **Earthwork Quantities** JOB # HALIFAX-12-1 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 were calculated by taking design thicknesses and/or cross sections and multiplying by design areas and/or lengths. Areas and lengths were determined using AutoCAD, a planimeter, and/or direct measurement.

PROJECT Halifax County C&D Landfill

SUBJECT Earthwork Quantities - Summary

SHEET 2/3
JOB # HALIFAX-12-1
DATE 12/12/2012
COMPUTED BY PKS
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Landfill Unit	Area (Acres)	General Earthwork		Periodic Cover (CY)	Compacted Soil Barrier (CY)		Vegetative Soil Layer (CY)
		Cut (CY)	Fill (CY)				
Area 1	6.5	-----	-----	1,627	-----		20,973
Area 2 - Phase 1	5.7	81,145	8,644	7,313	-----		-----
Area 2 - Phase 2	-----	-----	-----	8,331	3,630		3,630
Area 2 - Phase 3	-----	-----	-----	8,224	10,164		10,164
Totals (CY) =	**12.2**	**81,145**	**8,644**	**25,495**	**13,794**		**34,767**
Location (On-Site/Off-Site):		On-Site	On-Site	On-Site	On-Site		On-Site
						On-Site Soil Balance (CY) =	**(1,555)**

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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>	
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>	

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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 (apeak = 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:

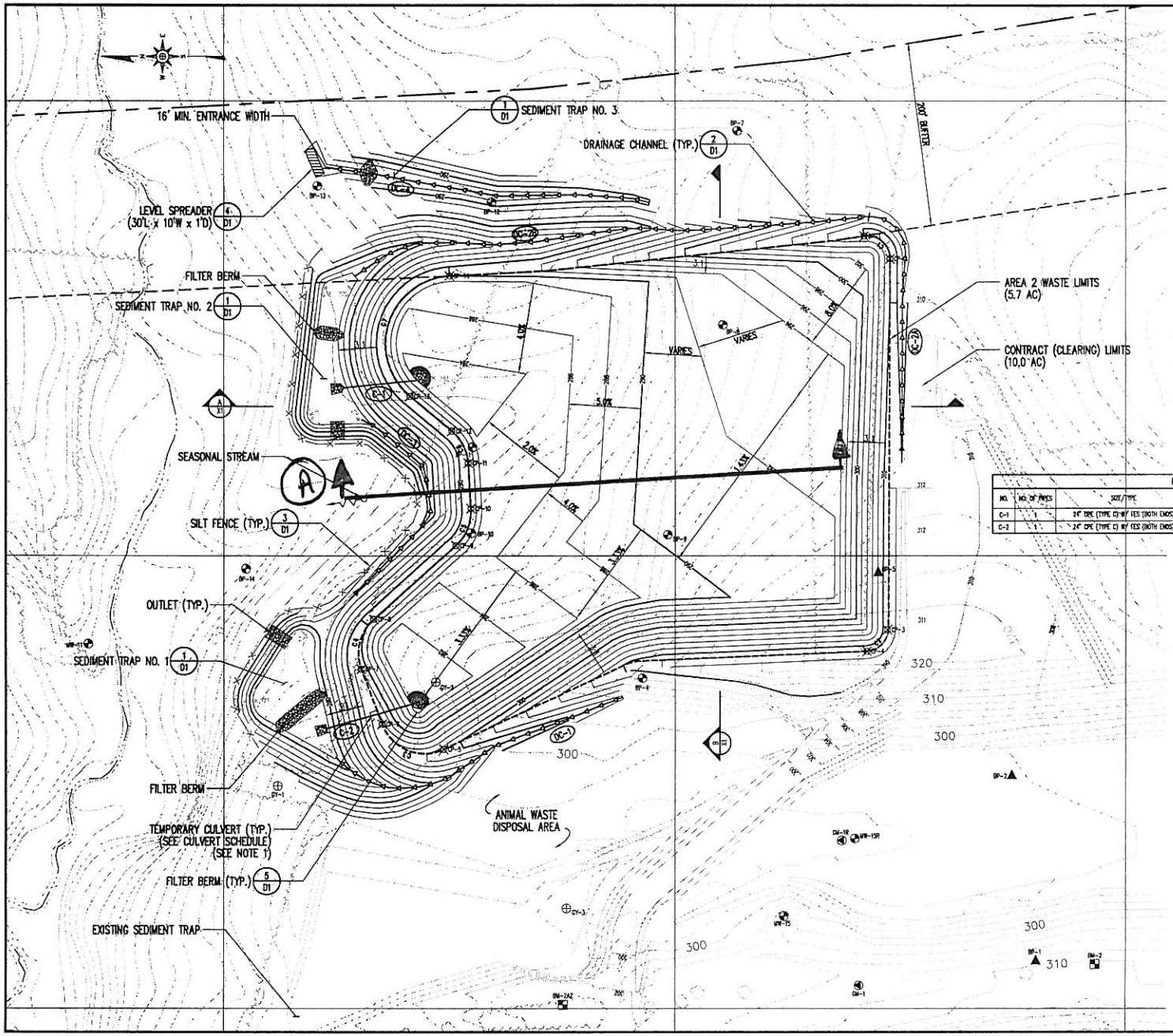
The slope stability evaluations for the overall C&D landfill area were performed using the computer program STABL5M, a computer program developed by Purdue University.

The slope stability evaluation was performed on the worst case cross section shown on the attached figures (base and 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/berms in this evaluation was cohesion = 0 psf and phi = 20 degrees; which is conservative as well. The result is as follows:

Circular Failure (Static): 1.84

RESULTS:

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



AREA 2 LIMIT OF WASTE COORDINATES		
NODE ID	NORTHING	EASTING
CP-1	957391.83	2350852.24
CP-2	957361.95	2350827.30
CP-3	957261.90	2350418.84
CP-4	957296.71	2350395.13
CP-5	957752.11	2350285.98
CP-6	957835.21	2350313.78
CP-7	957848.24	2350375.58
CP-8	957834.57	2350430.45
CP-9	957743.56	2350511.09
CP-10	957726.94	2350551.54
CP-11	957730.00	2350601.83
CP-12	957748.07	2350637.35
CP-13	957754.38	2350675.59
CP-14	957750.50	2350808.32

CURVE TABLE				
CURVE	DELTA	TANGENT (FT)	RADIUS (FT)	CHORD LENGTH (FT)
C1	99°27'36"	29.51	25.00	38.15
C2	87°37'36"	22.84	23.84	32.98
C3	94°47'36"	54.29	50.00	73.56
C4	64°51'41"	34.27	50.00	56.54
C5	51°54'38"	24.34	50.00	43.77
C6	48°57'34"	21.72	50.00	39.85
C7	137°29'24"	192.81	75.00	138.80

CULVERT SCHEDULE							
NO.	NO. OF PIPES	SIZE/TYPE	LENGTH (FEET)	SLOPE (%)	INV. IN (FEET)	INV. OUT (FEET)	REMARKS
C-1	1	24" CPE (TYPE C) W/ YES (BOTH ENDS)	80	10.0	283.0	273.0	OUTLETS IN ST-2
C-2	1	24" CPE (TYPE C) W/ YES (BOTH ENDS)	104	2.9	280.0	277.0	OUTLETS IN ST-1

LEGEND

- EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- PROPERTY LINE
- PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR
- B-1 GEOTECHNICAL BORING
- MW-10 EXISTING GROUND WATER MONITORING WELL
- GM-2 EXISTING LANDFILL GAS PROBE
- BM-1 BENCHMARK MONUMENT
- SW-1 EXISTING SURFACE WATER MONITORING LOCATION
- GV-2 EXISTING GAS VENT
- DC-1 DRAINAGE CHANNEL NUMBER
- C-1 CULVERT NUMBER
- SILT FENCE

NOTES

1. GROUT OR REMOVE TEMPORARY CULVERTS PRIOR TO WASTE PLACEMENT OVER AREA AROUND INLET.

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON FEBRUARY 1994 AERIAL PHOTOGRAPHY.
2. WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW SITE CONTOURS FROM SURVEY BY BURR & ASSOCIATES DATED SEPTEMBER 12, 2001.

0 50' 100' 150'

G. N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services
1414 Boylan Ave.
Raleigh, N.C. 27603
ph: 919-828-6677
fax: 919-828-3899
www.gnra.com

REVISION | NO. | DATE

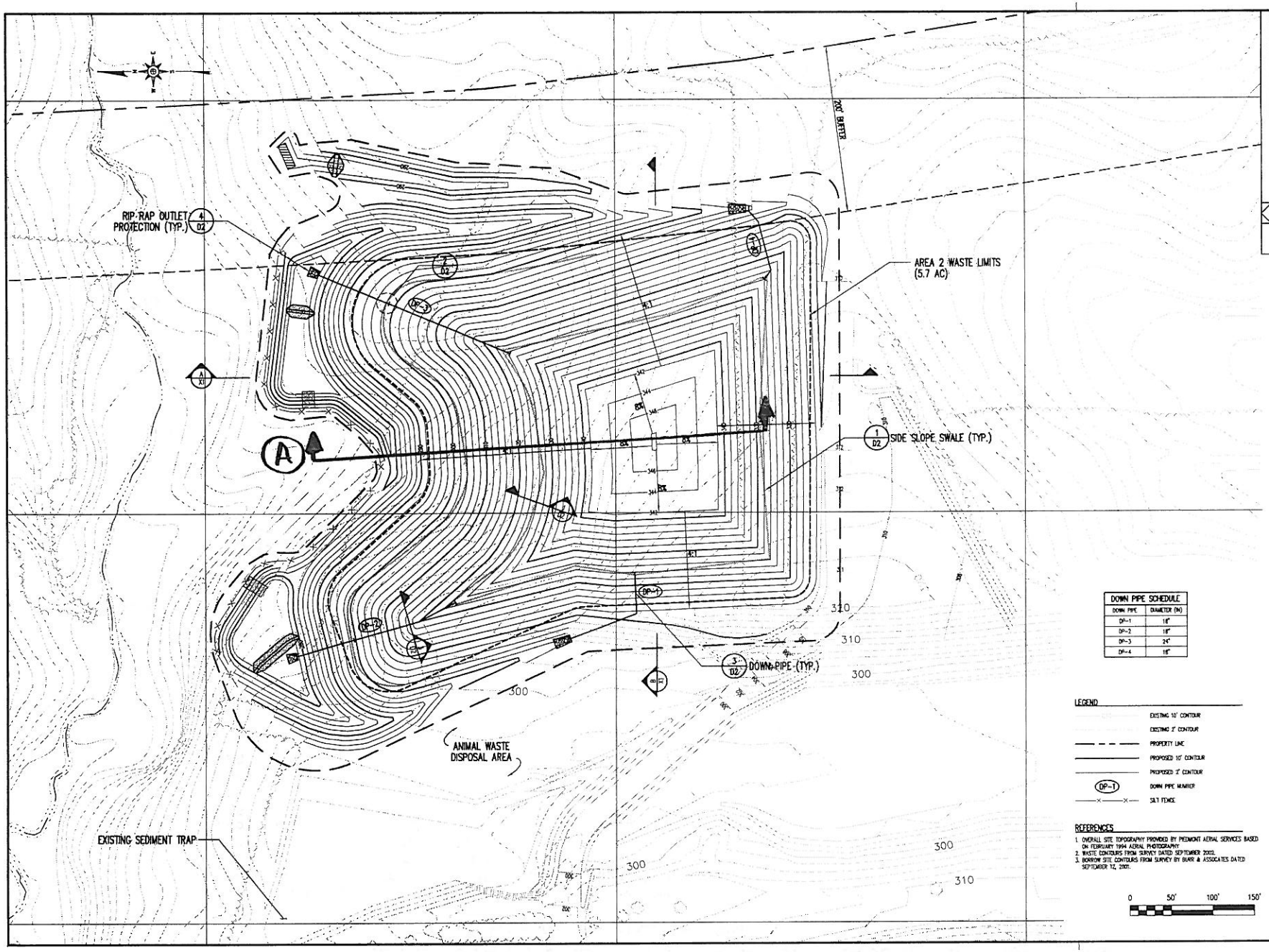
SEAL

PROJECT TITLE: HALIFAX COUNTY, NC C&D LANDFILL AREA 2

DRAWING TITLE: AREA 2 SUBGRADE GRADING AND DRAINAGE PLAN

DESIGNED BY: P.K.S.	DRAWN BY: J.A.L.
CHECKED BY:	PROJECT NO.: HALIFAX 01
SCALE: AS SHOWN	DATE: MARCH 2006
FILE NAME: HALI-DOWN	
SHEET NO.: 4	DRAWING NO.: S3

2/10



DOWN PIPE SCHEDULE	
DOWN PIPE	DIAMETER (IN)
DP-1	18"
DP-2	18"
DP-3	24"
DP-4	18"

LEGEND

- EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- PROPERTY LINE
- PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR
- DP-1 DOWN PIPE NUMBER
- SILT FENCE

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY PIEDMONT AERIAL SERVICES BASED ON FEBRUARY 1994 AERIAL PHOTOGRAPHY
2. WASTE CONTOURS FROM SURVEY DATED SEPTEMBER 2002.
3. BORROW SITE CONTOURS FROM SURVEY BY BURR & ASSOCIATES DATED SEPTEMBER 12, 2001.

0 50' 100' 150'

NO.	DATE	REVISION

G. N. RICHARDSON & ASSOCIATES, INC.
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14 N. Boylan Ave.
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fax: 919-828-3899

SEAL

SEAL

PROJECT TITLE: HALIFAX COUNTY, NC C&D LANDFILL AREA 2

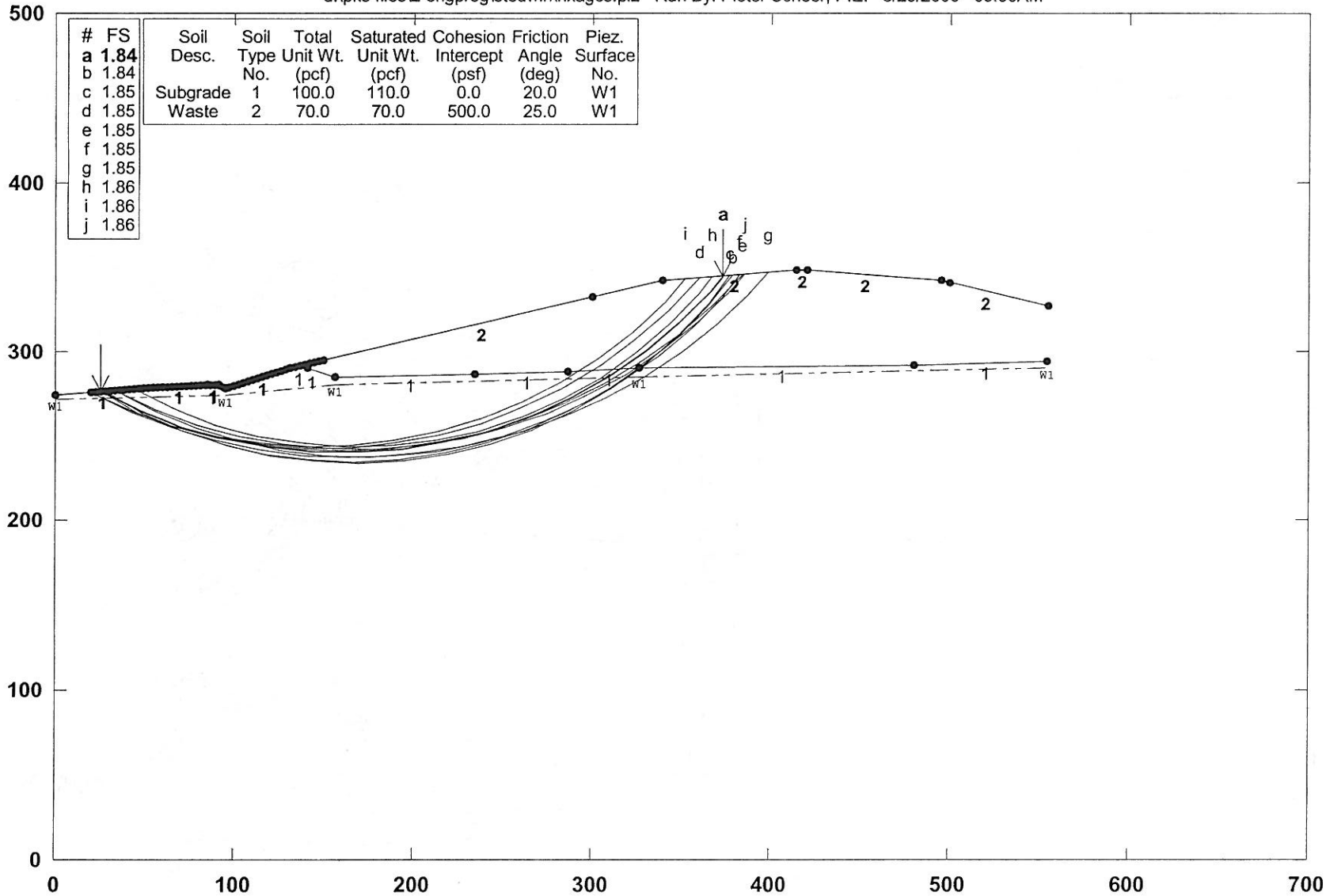
DRAWING TITLE: AREA 2 FINAL COVER GRADING AND DRAINAGE PLAN

DESIGNED BY: P.K.S.	DRAWN BY: J.A.L.
CHECKED BY:	PROJECT NO. HALIFAX 01
SCALE: AS SHOWN	DATE: MARCH 2006
FILE NAME: HALIDOWN	
SHEET NO. 5	DRAWING NO. S4

3/10

Halifax County C&D - Area 2 - Section A Global - Circular - Static

d:\pks files\2 engprog\stedwin\hxagcs.pl2 Run By: Pieter Scheer, P.E. 3/29/2006 09:56AM



PCSTABL5M/si FSmin=1.84

Safety Factors Are Calculated By The Modified Bishop Method

4/10

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

Run Date: 3/29/2006
Time of Run: 09:56AM
Run By: Pieter Scheer, P.E.
Input Data Filename: D:HXAGCS.IN
Output Filename: D:HXAGCS.OUT
Unit: ENGLISH
Plotted Output Filename: D:HXAGCS.PLT
PROBLEM DESCRIPTION Halifax County C&D - Area 2 - Section A
Global - Circular - Static

BOUNDARY COORDINATES
10 Top Boundaries
17 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	274.00	47.00	278.00	1
2	47.00	278.00	85.00	280.00	1
3	85.00	280.00	91.00	280.00	1
4	91.00	280.00	95.00	278.00	1
5	95.00	278.00	131.00	290.00	1
6	131.00	290.00	339.00	342.00	2

7	339.00	342.00	414.00	348.00	2
8	414.00	348.00	420.00	348.00	2
9	420.00	348.00	495.00	342.00	2
10	495.00	342.00	555.00	327.00	2
11	131.00	290.00	141.00	290.00	1
12	141.00	290.00	156.00	285.00	1
13	156.00	285.00	234.00	286.00	1
14	234.00	286.00	286.00	288.00	1
15	286.00	288.00	326.00	290.00	1
16	326.00	290.00	480.00	292.00	1
17	480.00	292.00	554.00	294.00	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	100.0	110.0	.0	20.0	.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	272.00
2	95.00	274.00
3	156.00	280.00
4	326.00	285.00
5	554.00	290.00

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 = 20.00 ft.
and X = 150.00 ft.
Each Surface Terminates Between X = 300.00 ft.
and X = 500.00 ft.
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = .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 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.31	276.15
2	47.50	264.64
3	70.67	255.25
4	94.60	248.04
5	119.11	243.08
6	143.97	240.42
7	168.96	240.08
8	193.88	242.06
9	218.52	246.34
10	242.64	252.89
11	266.06	261.65
12	288.56	272.55
13	309.95	285.49
14	330.05	300.35
15	348.68	317.02
16	365.69	335.35
17	372.88	344.71

Circle Center At X = 160.1 ; Y = 509.0 and Radius, 269.1
*** 1.842 ***
Individual data on the 29 slices

	Water	Water	Tie	Tie	Earthquake

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Slice No.	Width (ft)	Weight (lbs)	Force Top (lbs)	Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Force Hor (lbs)	Force Ver (lbs)	Surcharge Load (lbs)
1	6.7	1359.1	.0	.0	.0	.0	.0	.0	.0
2	15.0	13451.0	.0	4256.7	.0	.0	.0	.0	.0
3	.5	703.1	.0	288.9	.0	.0	.0	.0	.0
4	23.2	46378.3	.0	20741.2	.0	.0	.0	.0	.0
5	14.3	40981.9	.0	19193.5	.0	.0	.0	.0	.0
6	6.0	19414.1	.0	9314.6	.0	.0	.0	.0	.0
7	3.6	11913.1	.0	5958.0	.0	.0	.0	.0	.0
8	.4	1295.5	.0	655.6	.0	.0	.0	.0	.0
9	24.1	95109.6	.0	45314.5	.0	.0	.0	.0	.0
10	11.9	58283.3	.0	25634.0	.0	.0	.0	.0	.0
11	10.0	53261.4	.0	22959.2	.0	.0	.0	.0	.0
12	3.0	16332.8	.0	7055.4	.0	.0	.0	.0	.0
13	12.0	67362.7	.0	29202.5	.0	.0	.0	.0	.0
14	13.0	75017.4	.0	32365.5	.0	.0	.0	.0	.0
15	24.9	150331.8	.0	61876.1	.0	.0	.0	.0	.0
16	24.6	151185.5	.0	58130.0	.0	.0	.0	.0	.0
17	15.5	93466.6	.0	33652.1	.0	.0	.0	.0	.0
18	8.6	50971.8	.0	17149.2	.0	.0	.0	.0	.0
19	23.4	130914.1	.0	39953.4	.0	.0	.0	.0	.0
20	19.9	99497.4	.0	23565.7	.0	.0	.0	.0	.0
21	2.6	11768.3	.0	2114.2	.0	.0	.0	.0	.0
22	19.7	80765.4	.0	8161.8	.0	.0	.0	.0	.0
23	1.7	5978.7	.0	.0	.0	.0	.0	.0	.0
24	5.4	18360.0	.0	.0	.0	.0	.0	.0	.0
25	14.7	44310.0	.0	.0	.0	.0	.0	.0	.0
26	9.0	22888.8	.0	.0	.0	.0	.0	.0	.0
27	9.7	20122.5	.0	.0	.0	.0	.0	.0	.0
28	17.0	20559.3	.0	.0	.0	.0	.0	.0	.0
29	7.2	2213.2	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.31	276.15
2	46.90	263.55
3	69.61	253.09
4	93.22	244.88
5	117.52	238.99
6	142.27	235.48
7	167.24	234.38
8	192.21	235.70
9	216.93	239.42
10	241.17	245.52
11	264.72	253.93
12	287.33	264.58
13	308.81	277.37
14	328.96	292.18
15	347.58	308.86
16	364.50	327.27
17	377.96	345.12

Circle Center At X = 166.1 ; Y = 492.6 and Radius, 258.2

*** 1.843 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.96	276.38
2	49.36	263.46
3	71.95	252.74
4	95.48	244.31
5	119.74	238.26
6	144.48	234.66
7	169.45	233.54
8	194.42	234.90
9	219.12	238.75
10	243.32	245.03

```
   11        266.77      253.68
   12        289.25      264.63
   13        310.53      277.75
   14        330.39      292.93
   15        348.65      310.01
   16        365.12      328.81
   17        376.68      345.01
Circle Center At X =  168.2 ; Y =  484.6  and Radius,  251.1
      ***     1.847   ***
Failure Surface Specified By 17 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         20.00      275.70
    2         42.46      264.72
    3         65.84      255.86
    4         89.94      249.22
    5        114.55      244.83
    6        139.46      242.76
    7        164.46      243.00
    8        189.33      245.56
    9        213.85      250.42
   10        237.82      257.54
   11        261.02      266.84
   12        283.26      278.26
   13        304.34      291.70
   14        324.09      307.03
   15        342.33      324.13
   16        358.90      342.85
   17        359.47      343.64
Circle Center At X =  149.3 ; Y =  511.7  and Radius,  269.1
      ***     1.848   ***
Failure Surface Specified By 18 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         20.00      275.70
    2         42.53      264.86
    3         65.90      255.98
    4         89.93      249.11
    5        114.47      244.30
    6        139.32      241.60
    7        164.31      241.02
    8        189.27      242.57
    9        214.00      246.23
   10        238.33      251.98
   11        262.08      259.78
   12        285.09      269.56
   13        307.18      281.27
   14        328.19      294.81
   15        347.98      310.08
   16        366.40      326.99
   17        383.32      345.39
   18        383.45      345.56
Circle Center At X =  158.6 ; Y =  534.9  and Radius,  294.0
      ***     1.849   ***
Failure Surface Specified By 17 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         33.27      276.83
    2         55.12      264.69
    3         78.03      254.69
    4        101.80      246.93
    5        126.19      241.47
    6        151.00      238.37
    7        175.99      237.65
    8        200.93      239.32
    9        225.60      243.37
   10        249.78      249.75
```

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```
   11        273.23      258.42
   12        295.74      269.28
   13        317.11      282.25
   14        337.15      297.20
   15        355.67      314.00
   16        372.50      332.48
   17        382.21      345.46
Circle Center At X =  171.0 ; Y =  499.0  and Radius,  261.4
      ***     1.850   ***
Failure Surface Specified By 18 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         20.00      275.70
    2         42.27      264.33
    3         65.40      254.86
    4         89.25      247.37
    5        113.64      241.89
    6        138.41      238.47
    7        163.37      237.13
    8        188.36      237.89
    9        213.20      240.73
   10        237.71      245.64
   11        261.73      252.59
   12        285.08      261.52
   13        307.60      272.37
   14        329.14      285.07
   15        349.54      299.52
   16        368.66      315.63
   17        386.36      333.28
   18        397.74      346.70
Circle Center At X =  166.8 ; Y =  535.3  and Radius,  298.2
      ***     1.854   ***
Failure Surface Specified By 16 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         43.88      277.73
    2         66.00      266.08
    3         89.19      256.75
    4        113.21      249.82
    5        137.81      245.38
    6        162.74      243.46
    7        187.73      244.10
    8        212.53      247.28
    9        236.87      252.96
   10        260.51      261.10
   11        283.20      271.60
   12        304.69      284.36
   13        324.78      299.25
   14        343.25      316.10
   15        359.90      334.75
   16        366.77      344.22
Circle Center At X =  168.9 ; Y =  487.9  and Radius,  244.5
      ***     1.856   ***
Failure Surface Specified By 16 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         20.00      275.70
    2         42.50      264.79
    3         65.92      256.07
    4         90.07      249.61
    5        114.73      245.46
    6        139.66      243.68
    7        164.66      244.26
    8        189.48      247.22
    9        213.91      252.52
   10        237.73      260.11
   11        260.73      269.92
```

```
   12        282.68      281.87
   13        303.41      295.86
   14        322.72      311.74
   15        340.43      329.38
   16        351.74      343.02
Circle Center At X =  145.9 ; Y =  506.3  and Radius,  262.8
      ***     1.856   ***
Failure Surface Specified By 17 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         33.27      276.83
    2         55.68      265.76
    3         79.00      256.74
    4        103.02      249.83
    5        127.57      245.10
    6        152.44      242.58
    7        177.44      242.29
    8        202.37      244.23
    9        227.02      248.39
   10        251.20      254.74
   11        274.72      263.22
   12        297.38      273.77
   13        319.02      286.30
   14        339.45      300.71
   15        358.51      316.88
   16        376.05      334.70
   17        385.08      345.69
Circle Center At X =  168.2 ; Y =  521.8  and Radius,  279.7
      ***     1.856   ***
```

OBJECTIVE: To estimate the foundation settlement due to the planned waste loads. A worst-case point (maximum waste load) was assumed.

REFERENCES:

Holtz, R.D., & Kovacs, W.D. (1981), An Introduction To Geotechnical Engineering, Prentice-Hall, Englewood Cliffs, NJ, Chapters 8 and 9.

Ohio EPA - Geotechnical Resource Group (2004), "Geotechnical and Stability Analyses for Ohio Waste Containment Facilities", Ohio EPA, Columbus, Ohio, Chapter 6.

Quian, X., Koerner, R.M., & Gray, D.H. (2001), Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, Upper Saddle River, N.J., pp. 310, 469-473.

ASSUMPTIONS:

1. Vertical stresses acting on the liner are assumed to be one-dimensional (1-D).
2. Assumptions for soil properties are listed in the attached spreadsheet.

ANALYSIS: The following approach is used to perform the evaluation:

1. Identify the critical cross section(s) to be evaluated (maximum waste fill, minimum liner slopes, etc.).
2. Select points along each cross section to perform calculations (points of grade breaks in final cover and/or liner system).
3. For each calculation point, determine the subsurface profile beneath the liner system and separate into distinct layers (thickness and material properties) (Include structural fill where applicable).
4. For each calculation point, determine the stresses acting on the midpoint of each layer both before and after construction.
5. For each calculation point, determine the stress change at the subgrade. Take into account the stress decrease due to excavation (where applicable) and the stress increase due to waste loads.
6. Calculate elastic settlements for each granular soil layer using the equations below.
7. Calculate consolidation (primary and secondary) settlements for each clay/silt soil layer using the equations below.
8. Calculate total settlements at each calculation point and resulting elevations.

CALCULATIONS:

- Elastic Settlement Equation:

$$S_e = \frac{\Delta p}{M_S} H$$

where:

S_e = elastic settlement (ft)
Δp = net stress change acting on middle of soil layer (psf)
M_s = constrained modulus of soil (psf)

$$M_S = \frac{E_S(1-\upsilon_S)}{(1+\upsilon_S)(1-2\upsilon_S)}$$

E_s = elastic modulus of soil (psf)
v_s = Poisson's ratio of soil
H = initial thickness of soil layer (ft).

- Primary Consolidation Settlement Equations:

for $p'_O + \Delta p \geq p'_{mp}$

$$S_C = H\left(C_{r\varepsilon} \log \frac{p'_{mp}}{p'_o} + C_{c\varepsilon} \log \frac{p'_o + \Delta p}{p'_{mp}} \right)$$

for $p'_O + \Delta p < p'_{mp}$

$$S_C = H\left(C_{r\varepsilon} \log \frac{p'_o + \Delta p}{p'_o} \right)$$

where:

S_c	=	primary consolidation settlement (ft)
H	=	initial thickness of soil layer (ft)
p'_{mm}	=	maximum past consolidation pressure (psf)
p'_o	=	effective vertical stress in middle of soil layer afer excavation, but before loading (psf)
Δp	=	net stress change acting on middle of soil layer (psf).
$C_{r\varepsilon}$	=	modified recompression index

$$C_{r\varepsilon} = \frac{C_r}{1 + e_o}$$

$C_{c\varepsilon}$	=	modified primary compression index

$$C_{c\varepsilon} = \frac{C_c}{1 + e_o}$$

C_r	=	recompression index
C_c	=	primary compression index
e_0	=	initial void ratio

- Secondary Consolidation Settlement Equation:

$$S_s = C_{s\varepsilon} H \log \frac{t_s}{t_{pf}}$$

where:

S_s	=	secondary consolidation settlement (ft)
$S_{s\varepsilon}$	=	modified secondary compression index
H	=	initial thickness of soil layer (ft)
t_s	=	time over which secondary settlement is to be calculated (typ. this is a max. of 100 years plus the max. time to complete primary consolidation)
t_{pf}	=	time to complete primary consolidation

$$t_{pf} = \frac{T_V * H_t^2}{C_V}$$

T_V	=	dimensionless time factor associated with the time it takes for primary consolidation settlement to be completed

$$For U < 60\%: \; T_V = \frac{\pi}{4}\left(\frac{U\%}{100}\right)^2$$

$$For U \geq 60\%: \; T_V = 1.781 - 0.933 \log(100 - U\%)$$

H_t	=	maximum length of drainage in the consolidating layer (= H for single-drained; = 0.5H for double-drained)
C_V	=	coefficient of consolidation (ft^2/year)
U	=	percent of primary consolidation (%) (typ. max. is 99.999; results in TV = 4.58).

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- Total Settlement Equation:

$$S_{Total} = S_e + S_c + S_s$$

where:
S_{Total} = total settlement (ft)
S_e = elastic settlement (ft)
S_c = primary consolidation settlement (ft)
S_s = secondary consolidation settlement (ft).

- Liner Strain Equation (where applicable):

$$E_T = \frac{L_f - L_o}{L_o} \times 100$$

where:
E_T = total strain (%) ("+" = tension; "-" = compression)
L_o = original distance separating two adjacent calculation points (ft)
L_f = final distance separating two adjacent calculation points after settlement is complete (ft).

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PROJECT	**Halifax County C&D Landfill - Area 2**	SHEET	4/10
SUBJECT	**Settlement Analysis - Worst Case Point**	JOB #	HALIFAX-12-3
		DATE	12/12/2012
		COMPUTED BY	PKS
		CHECKED BY	

Soils Information: (Note: When elastic or consolidation settlement is not applicable to a particular layer, enter "NA" for requested parameters.)

Soil Layer	Description	Dry Unit Wt. (pcf)	Natural Moisture Content (%)	Wet Unit Wt. (pcf)	Elastic Settlement Parameters E_s (psf)	n_s	M_s (psf)	Consolidation Settlement Parameters OCR	C_{ce}	C_{re}	C_{se}
1	Sandy Silt; Silty Clay	95.8	23.0	117.8	NA		NA	1.3	0.06	0.006	0.002

Waste Information:

Average Unit Weight, γ_{Waste} (pcf) = 60

Assumptions:

Soil Propoerties are based on consolidation test data from BP-8 (Labeled as B-8 on Test Report)

Dry Unit Weight (pcf): 95.8

Natural moisture content (%), w_n : 23.0

OCR: 1.3 (based on p'_{mp} = 900 psf and assuming 6' depth at 117.8 pcf)

Modified primary compression index (dimensionless), C_{ce} : 0.13

Modified recompression Index (dimensionless), C_{re} : 0.014

Modified secondary compression index (dim'less), C_{se} : 0.002 (estimated as w_n x 0.0001, w_n = 23%)

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PROJECT	**Halifax County C&D Landfill - Area 2**	SHEET	5/10
		JOB #	HALIFAX-12-3
SUBJECT	**Settlement Analysis - Worst Case Point**	DATE	12/12/2012
		COMPUTED BY	PKS
		CHECKED BY	

Settlement Points - Location Information:

Parameter	Point 1	2	3	4	5	6	7	8	9	10	11	12
Position:	0											
Original Ground Surface Elevation (ft) =	302.0											
Avg. Unit Wt. of Soil Excavated (pcf) =	115.0											
Top of Landfill Elevation (ft) =	350.0											
Top of Subgrade Elevation (ft) =	291.0											
Top of Groundwater Elevation (ft) =	286.0											
Layer 1: Thickness (ft) =	40.0											
Elevation of Mid Point (ft) =	271.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	2,686											
p'_{mp} at Mid Point (psf) =	3,491											
(After Liner Construct.) p'_o at Mid Point (psf) =	1,421											
Layer 2: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 3: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 4: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 5: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 6: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 7: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 8: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 9: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											
Layer 10: Thickness (ft) =	0.0											
Elevation of Mid Point (ft) =	251.0											
(Before Liner Construct.) p'_o at Mid Point (psf) =	3,794											
p'_{mp} at Mid Point (psf) =	0											
(After Liner Construct.) p'_o at Mid Point (psf) =	2,529											

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PROJECT	**Halifax County C&D Landfill - Area 2**	SHEET	6/10
		JOB #	HALIFAX-12-3
SUBJECT	**Settlement Analysis - Worst Case Point**	DATE	12/12/2012
		COMPUTED BY	PKS
		CHECKED BY	

Stress Change, *Dp*, at Liner:

Parameter	Point 1	2	3	4	5	6	7	8	9	10	11	12
Stress Decrease From Excavation (psf) =	1,265											
Stress Increase From Waste Load (psf) =	3,540											
Net Stress Increase/Decrease, D_p (psf) =	2,275											

Elastic Settlement:

Parameter	Point 1	2	3	4	5	6	7	8	9	10	11	12
Elastic Settlement (ft):												
Layer 1: S_e =	**NA**											
Layer 2: S_e =	**NA**											
Layer 3: S_e =	**NA**											
Layer 4: S_e =	**NA**											
Layer 5: S_e =	**NA**											
Layer 6: S_e =	**NA**											
Layer 7: S_e =	**NA**											
Layer 8: S_e =	**NA**											
Layer 9: S_e =	**NA**											
Layer 10: S_e =	**NA**											
Total Elastic Settlement (ft) =	**0.00**											

Elastic Settlement Equation:

$$Se = \frac{\Delta p}{M_S} H$$

Primary Consolidation Settlement:

Parameter	Point 1	2	3	4	5	6	7	8	9	10	11	12
Primary Consolidation Settlement (ft):												
Layer 1: S_c =	**0.16**											
	C											
Layer 2: S_c =	**NA**											

Layer 3: S_c =	**NA**											

Layer 4: S_c =	**NA**											

Layer 5: S_c =	**NA**											

Layer 6: S_c =	**NA**											

Layer 7: S_c =	**NA**											

Layer 8: S_c =	**NA**											

Layer 9: S_c =	**NA**											

Layer 10: S_c =	**NA**											

Total Primary Consol. Settlement (ft) =	**0.16**											

Primary Consolidation Settlement Equations:

For primary recompression and compression (designated C):

$$S_C = H\left(C_{r\varepsilon}\log\frac{p'_{mp}}{p'_o} + C_{c\varepsilon}\log\frac{p'_o+\Delta p}{p'_{mp}}\right)$$

For primary recompression only (designated R):

$$S_C = H\left(C_{r\varepsilon}\log\frac{p'_o+\Delta p}{p'_o}\right)$$

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PROJECT	**Halifax County C&D Landfill - Area 2**	SHEET	7/10
SUBJECT	**Settlement Analysis - Worst Case Point**	JOB #	HALIFAX-12-3
		DATE	12/12/2012
		COMPUTED BY	PKS
		CHECKED BY	

Secondary Consolidation Settlement:

Assumed % Primary Consolidation (U) = 99.999 **(Max. = 99.999)**

T_v (dimensionless) = 4.58

$t_s = t_{pf}$ + "X" (years) = 100

Parameter		Point 1	2	3	4	5	6	7	8	9	10	11	12
Secondary Consolidation Settlement (ft):													
Layer 1:	Drainage* =	1											
	H_t (ft) =	40.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	40.2											
	S_s =	**0.04**											
Layer 2:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 3:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 4:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 5:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 6:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 7:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 8:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.050											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 9:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.000											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Layer 10:	Drainage* =	1											
	H_t (ft) =	0.0											
	C_v (in^2/min) =	0.000											
	t_{pf} (years) =	0.0											
	S_s =	**NA**											
Total Sec. Consol. Settlement (ft) =		**0.04**											

* Single-Drained = 1; Double-Drained = 2

Secondary Consolidation Settlement Equation:

$$S_s = C_{sc} H \log \frac{t_s}{t_{pf}}$$

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PROJECT	**Halifax County C&D Landfill - Area 2**	SHEET	8/10
SUBJECT	**Settlement Analysis - Worst Case Point**	JOB #	HALIFAX-12-3
		DATE	12/12/2012
		COMPUTED BY	PKS
		CHECKED BY	

Total Settlement:

Parameter		Point 1	2	3	4	5	6	7	8	9	10	11	12
Total Settlement (ft):													
Layer 1:	S_{Total} =	**0.20**											
Layer 2:	S_{Total} =	**0.00**											
Layer 3:	S_{Total} =	**0.00**											
Layer 4:	S_{Total} =	**0.00**											
Layer 5:	S_{Total} =	**0.00**											
Layer 6:	S_{Total} =	**0.00**											
Layer 7:	S_{Total} =	**0.00**											
Layer 8:	S_{Total} =	**0.00**											
Layer 9:	S_{Total} =	**0.00**											
Layer 10:	S_{Total} =	**0.00**											
	Total Settlement (ft) =	**0.20**											

Total Settlement Equation:

$$S_{Total} = S_e + S_c + S_s$$

Before & After Elevations:

Parameter	Point 1	2	3	4	5	6	7	8	9	10	11	12
Position:	0											
Before Settlement:												
Top of Liner Elevation (ft) =	291.0											
After Settlement:												
Top of Liner Elevation (ft) =	290.8											
Comments:												

Liner Strain Equation:

$$E_r = \frac{L_f - L_o}{L_o} \times 100$$

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GeoTechnologies, Inc.

CONSOLIDATION TEST

Job Name: HALIFAX 5 Date: 4/16/96

Job Number: 1-95-1181 CB

Sample I.D. B - 8 - 1 Depth: 5 - 7'

Soil Description: RED ORANGE CLAYEY SAND

Notes: PRELOAD 500 \ SATURATED \ UNDISTURBED

RING PROPERTIES		
Diameter	2.5	inches
Height	1	inches
Volume	0.00284	cu.ft.
Weight	110.48	grams
Ring + Soil	262.34	grams

SOIL PROPERTIES		
Init. Moisture	23.0	%
Soil Weight.	151.9	grams
Wet Density	117.9	lbs./cu.ft.
Dry Density	95.8	lbs./cu.ft.
Specific Gravity	2.68	Apparent
Final Moisture	24.9	%

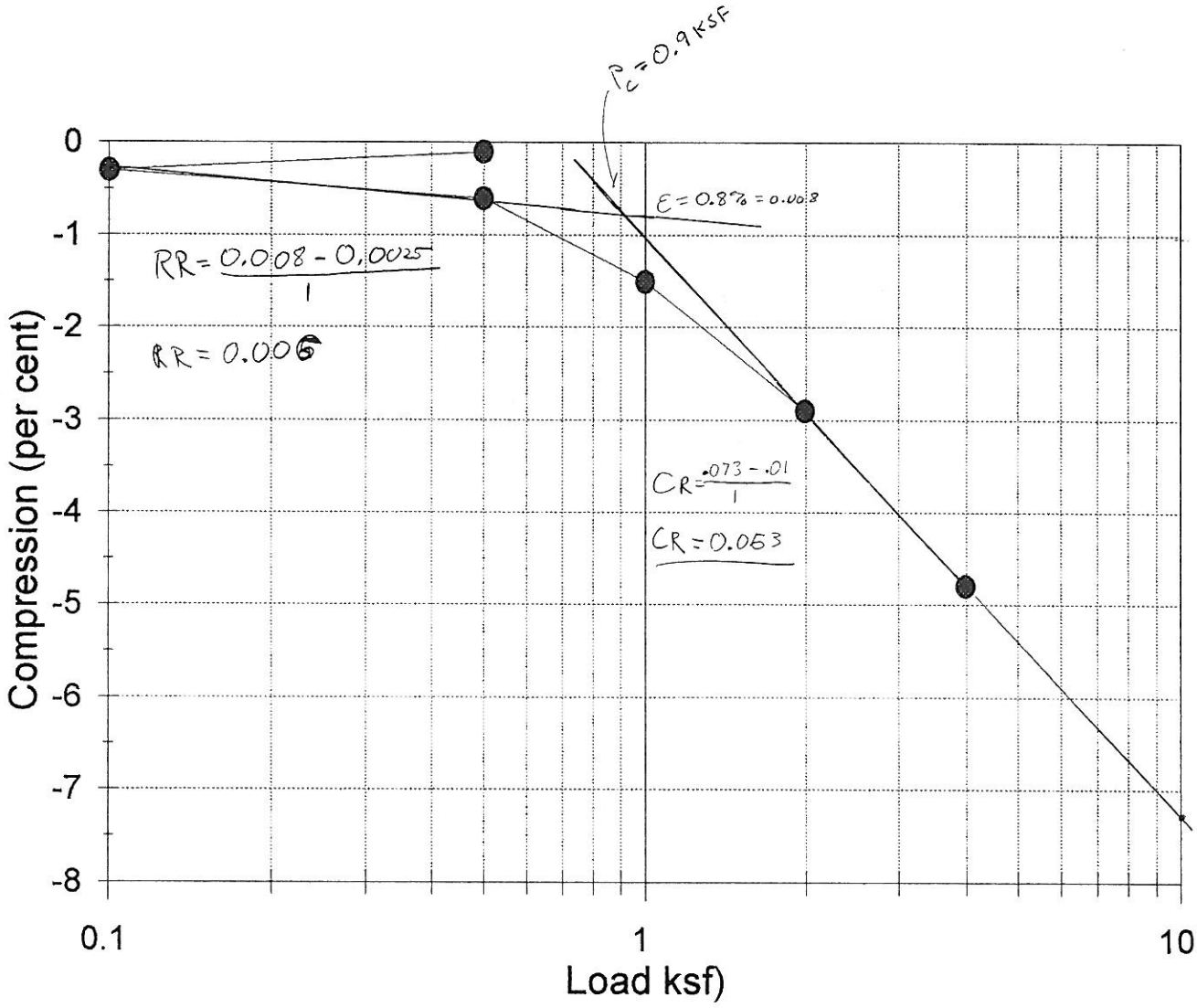
Initial Reading	.0000
Preload Rebound Reading	.0032

LOAD / psf	R0	R6	R100	T50	R50
100	.0000	.0004	.0005		
500	.0005	.0030	.0032		
100	.0032	.0008	.0006		
500	.0006	.0029	.0030		
1000	.0030	.0060	.0064	0.9	0.0047
2000	.0064	.0142	.0151	0.45	0.01075
4000	.0151	.0269	.0285	0.9	0.0218
8000	.0285	.0457	.0479	0.45	0.0382

LOAD / psf	%E	Con. Coef.	%IC
100	0.1		80.0
500	0.3		92.6
100	0.1		92.3
500	0.3		95.8
1000	0.6	5.421	88.2
2000	1.5	10.710	89.7
4000	2.9	5.236	88.1
8000	4.8	10.124	88.7
16000			

NOTE: Consolidation Coefficient in Square Feet Per Day

Initial Void Ratio	0.746
Final Void Ratio	0.662
Initial Saturation, %	82.6
Final Saturation, %	97.0

Consolidation Test

B-8, 5'-7'