DOC ID 15178
9-19-11 51-03
DW

Permit Modification Application

Johnston County C&D Landfill Vertical Expansion
Johnston County, North Carolina

APPROVED
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION
DATE 8-1-05 BY JMS
5103 P70
A3P3DOC2

Prepared For:

Johnston County Department of Public Utilities
309 East Market Street
Smithfield, North Carolina 27577

Prepared By:

G.N. Richardson & Associates, Inc.
Engineering and Geological Services
14 N. Boylan Avenue
Raleigh, North Carolina 27603

December 2003
Revised: August 2005

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

August 1, 2005

APPROVED
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION
DATE 8-1-05 BY JMB
5103 PTO
A3 P3 DOC 2

Mr. Edward F. Mussler, III, P.E.
Environmental Engineer
NC DENR Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, North Carolina 27605

RE: Johnston County Landfill
Request for Permit Modification (Original - December 2003; Revised - August 2005)
C & D Landfill Vertical Expansion Over Phase 4 MSW Landfill

Dear Ed:

On behalf of Johnston County, G.N. Richardson & Associates (GNRA) would like to submit an application to expand their existing construction and demolition debris (C&D) vertical expansion over closed portions of the Phase 4 MSW landfill disposal area at the Johnston County Landfill facility near Smithfield.

Proposed Modifications

Johnston County would like to expand their C&D unit over Phase 4 to ensure the maximum operation of this unit. The maximum limits of the proposed expansion are shown on **Drawing S2** (Final Cover Plan) of the attached project drawings. The expansion will add approximately 213,900 cubic yards of gross volume to the last approved modification (January 22, 2002). The phasing of this expansion, as shown on **Drawing P1** (Phasing Plan), will allow the landfill to be able to be closed at any time with a minimal footprint and only minor required adjustments to the final slopes in preparation for closure.

The attached life expectancy calculations show that, based on the proposed filling sequence described above, the landfill expansion will last until approximately October, 2006. At that time, Johnston County intends to move C&D operations into a new lined C&D landfill unit to be permitted and constructed within Borrow Area A.

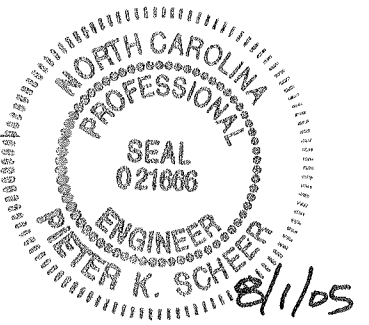
Also included in this plan is a request to allow the use of 30 mil textured LLDPE geomembrane as an alternate to the use of geosynthetic clay liner (GCL) in the final cover system of the landfill. The geomembrane, the same as generally used in closure of lined MSW landfills, will allow minimal infiltration through the final cover (similar to the GCL barrier already approved) and offers the County some additional flexibility in selecting the most cost effective system for closure. Infiltration calculations are provided in **Attachment A**. Because of this change and due to the time since the original permit in 1998, updated technical specifications and an updated CQA Manual are provided as **Attachments B and C**, respectively.

Revised Drawings and Erosion and Sedimentation Control Plan

Based on the modifications discussed above, updates to the permit for this facility include a revised erosion and sedimentation control plan (**Attachment D**) and a revised set of project drawings (**Attachment E**). The revised project drawings display revised erosion and sedimentation control information, revised details and cross sections, and the revised phasing plan.

Please contact us at your convenience with any further questions or comments which you may have on this permit application.

Sincerely,
G.N. Richardson & Associates, Inc.



Pieter K. Scheer, P.E.
Project Manager

Attachments:
A. Calculations
B. Technical Specifications
C. CQA Manual
D. Erosion & Sedimentation Control Plan
E. Permit Modification Drawings

cc: Haywood Phthisic, Johnston County
Rick Proctor, Johnston County
Tim Broome, Johnston County

PROJECT Johnston County - CDLF Expansion

SUBJECT Landfill Life Expectancy

SHEET 1 OF 4
JOB NO. JOHNSTON-21
DATE 12/5/03 (Rev. 7/28/05)
COMPUTED BY PKS
CHECKED BY

Objective To determine the expected life of the proposed C&D expansion given the proposed contours and estimated waste acceptance rates.

Assumptions
1. Density of Waste.
2. Waste to Periodic Cover (i.e. daily and intermediate) Ratio.
3. Waste Generation/Disposal Rates

Analysis AutoCAD was used to generate volumes.

LIFE.WPD

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

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

SHEET: 2.4
JOB #: JOHNSTON-21
DATE: 7/28/05
BY: PKS
CHKD BY:

Johnston County C&D Landfill - Area 1 (Vertical Expn.)
Volume Study: Filling Rate & Density Calculations

Density and Filling Rate Calculations:

Period of Interest 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)
4/1/1999	5/21/2004	5.14	343,193	187,514	**1,093**	10	34,319	308,874	**1,214**
5/22/2004	3/21/2005	0.83	48,788	25,654	**1,052**	10	4,879	43,909	**1,169**
								Avg. =	**1,191**

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

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

SHEET: 3/4
JOB #: JOHNSTON-21
DATE: 8/1/05
BY: PKS
CHKD BY:

Johnston County C&D Landfill - Area 1 (Vertical Expn.)
Volume Study: Life Expectancy Calculations

Waste & Periodic Cover Parameters:

Annual Tonnage =	42,548	(Worst Case Fiscal Year - 2001-02)
Waste Density (pcy) =	1,191	(From Filling Rate and Density Calcs.)
Waste Density (tcy) =	0.60	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) =	180,753	

Adjustment For Other Layers:

Area of Final Cover (Ac.) =	16.2	
2 feet (Avg.) Final Cover =	52,272	cy
Sum =	52,272	cy

Volume of Waste and Periodic Cover (cy) =	128,481	
Volume of Periodic Cover (cy) =	12,848	
Volume of Waste (cy) =	115,633	
Quantity of Waste (tons) =	68,859	
Landfill Life Expectancy (years) =	1.6	(From 3/21/05)

2 Oct. 2006

4/4

volume report 072405.txt

Johnston County Landfill

Project: land projects Sun July 24 22:47:25 2005

Site Volume Table: Unadjusted

Cut yards	Fill yards	Net yards	Method

Site: AIRSPACE CHANGED AREAS

MSW area volume represents latest aerial topo (I didn't know the date) vs. the 052104 topo with phase 4A cell 2 grades pasted in.

If you look at the isopach, a lot of the cut occurs around the perimeter of cell 2. As expected, the majority of the fill is in cell 1.

Stratum: msw area topo-052104-cell2-paste survey-msw-area

12,817	200,019	187,202 (F)	Composite

← Ignore - Cell 2

MSW remaining represents latest survey vs. phase 4A fill sequence 2, (shown in figure 2).

Stratum: msw area remaining topo-052104-changed-areas-paste phase4a-fill-seq-3

4,852	597,179	592,327 (F)	Composite

← Ignore - Perimeter

C&D area volume represents the two dates, latest (date unknown) vs. 052104.

The C&D volume is straight forward, fill is on top and west side.

Stratum: cd area topo-052104-cell2-paste survey-cd-area

1,282	50,070	48,788 (F)	Composite

← OK

CD remaining represents latest survey vs. final cover grades, (shown in figure 2)

Stratum: cd area remaining topo-052104-changed-areas-paste cd-fcvr-120503

7149	187902	180753 (F)	Composite

← OK

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

December 12, 2003

Mr. Edward F. Mussler, III, P.E.
Environmental Engineer
NC DENR Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, North Carolina 27605

RE: Johnston County Landfill
Request for Permit Modification
C & D Landfill Vertical Expansion Over Phase 4 MSW Landfill

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Also included in this plan is a request to allow the use of 30 mil textured LLDPE geomembrane as an alternate to the use of geosynthetic clay liner (GCL) in the final cover system of the landfill. The geomembrane, the same as generally used in closure of lined MSW landfills, will allow minimal infiltration through the final cover (similar to the GCL barrier already approved) and offers the County some additional flexibility in selecting the most cost effective system for closure. Infiltration calculations are provided in **Attachment A**. Because of this change and due to the time since the original permit in 1998, updated technical specifications and an updated CQA Manual are provided as **Attachments B and C**, respectively.

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Sincerely,
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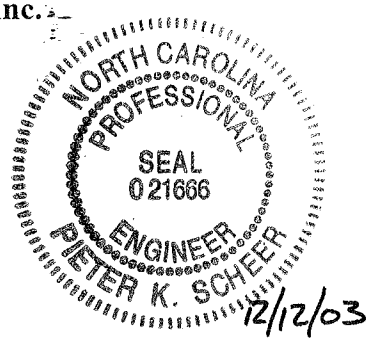

Pieter K. Scheer, P.E.
Project Manager

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E. Permit Modification Drawings

cc: Haywood Phthisic, Johnston County
Rick Proctor, Johnston County
Tim Broome, Johnston County

Attachment A

Calculations

JOHNSTON COUNTY
C&D LANDFILL VERTICAL EXPANSION

PERMIT MODIFICATION APPLICATION
ATTACHMENT A: CALCULATIONS

TABLE OF CONTENTS

PROJECT Johnston County - CDLF Expansion

SUBJECT Landfill Life Expectancy

SHEET 1 OF 3
JOB NO. JOHNSTON-21
DATE 12/5/03
COMPUTED BY PKS
CHECKED BY

Objective To determine the expected life of the proposed C&D expansion given the proposed contours and estimated waste acceptance rates.

Assumptions
1. Density of Waste.
2. Waste to Periodic Cover (i.e. daily and intermediate) Ratio.
3. Waste Generation/Disposal Rates

Analysis AutoCAD was used to generate volumes.

LIFE.WPD

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

G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2 / 3
JOB #: JOHNSTON-21
DATE: 12/12/03
BY: PKS
CHKD BY:

Johnston Co. Landfill - Phase 4 C&D Expn.
Analysis of Life Expectancy

Waste Parameters:

Unit Weight (pcy) =	1000
Unit Weight (tcy) =	0.5
Percentage of Periodic Cover =	10
Area of Waste Footprint (Ac.) =	16.25

Waste Loading Parameters:

Projected Annual Tonnage = 45000

Volume Calculations:

Volume From AutoCAD = 213889 cy (Expansion) (See Attached)

Adjustment For Other Layers:

1.5 feet (Avg.) of Final Cover = 39325 cy

Sum = 39325 cy

Volume of Waste and Periodic Cover (cy) = 174564

Volume of Periodic Cover (cy) = 17456

Volume of Waste (cy) = 157108

Volume of Waste (tons) = 78554

Landfill Life Expectancy (years) = 1.7 → 2004 + 1.7 = 2005.7

→ SEPT, 2005 = FULL

LIFE.WB3

volume-report-121103.txt

Johnston County C&D Vertical Expansion

Project: LAND PROJECTS Thu December 11 17:51:21 2003

Site Volume Table: Unadjusted

Cut yards	Fill yards	Net yards	Method
Site: CD VERTICAL EXPN 1203			
Stratum: C&D VERTICAL EXPANSION 12/03 AIRSPACE			
1	213,890	213,889 (F)	Composite

Previously Permitted Volumes: 128,041 CY (1998)
226,089 CY (2002)
Σ = 354,130

$\Sigma_{\text{TOTAL (GROSS)}} = 354,130 + 213,889 = 568,019$ CY

PROJECT Johnston County - C&D Landfill Vertical Expn.

SUBJECT Final Cover Infiltration Analysis

SHEET 1 OF 35
JOB NO. JOHNSTON-21
DATE 12/9/03
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. Both 5% and 4H:1V (25%) slopes were analyzed. 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:

1. Proposed Final Cover System: (Top Down)

   A. 18 inches Vegetative Soil Layer
   B. Geonet Drainage Media
   C. GCL or 30 mil Textured LLDPE Geomembrane
   D. 12 inches Intermediate Cover

2. Regulatory Final Cover System: (Top Down)

   A. 6 inches Vegetative Soil Layer
   B. 18 inches Compacted Soil Barrier ($k = 1 \times 10^{-5}$ cm/sec)
   D. 12 inches Intermediate Cover

Results

Case	Slope of Final Cover System (percent)	Average Annual Infiltration (inches)
1A1 (GCL)	5.0	0.03
1A2 (GM)	5.0	0.04
1B1 (GCL)	25.0	0.03
1B2 (GM)	25.0	0.03
2A	5.0	15.48
2B	25.0	15.45

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

FINALCVRHELP3.WPD

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

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

PRECIPITATION DATA FILE:     C:\2ENGPR~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\2ENGPR~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\2ENGPR~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\2ENGPR~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\2ENGPR~1\HELP3\JC1A1.D10
OUTPUT DATA FILE:            C:\2ENGPR~1\HELP3\JC1A1.OUT

TIME:  16:36     DATE:  12/ 9/2003

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

     TITLE:  Johnston County C&DLF - Case 1A1 (5%  - GCL)

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

     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   7
        THICKNESS                      =     18.00   INCHES
        POROSITY                       =      0.4730 VOL/VOL
        FIELD CAPACITY                 =      0.2220 VOL/VOL
        WILTING POINT                  =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT     =      0.2329 VOL/VOL
        EFFECTIVE SAT. HYD. COND.      =  0.520000001000E-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	=	0.2094	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

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

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2014	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	75.40	
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	=	4.245	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.726	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.873	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.849	INCHES

TOTAL INITIAL WATER	=	6.849	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	0.038	0.002	0.011	0.002	0.046	0.010
	0.010	0.118	0.015	0.010	0.019	0.008
STD. DEVIATIONS	0.074	0.008	0.028	0.010	0.128	0.028
	0.035	0.362	0.060	0.035	0.050	0.025
EVAPOTRANSPIRATION						
TOTALS	1.486	1.785	2.998	2.702	3.887	3.635
	3.918	4.149	2.478	1.353	1.268	1.102
STD. DEVIATIONS	0.133	0.256	0.334	0.977	1.036	1.695
	1.464	1.260	1.163	0.428	0.162	0.139
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.0565	1.3209	1.0922	0.3377	0.5474	0.2177
	0.1375	1.0223	0.2306	0.5176	1.3327	1.3734
STD. DEVIATIONS	1.7428	1.0915	1.0603	0.6340	1.0940	0.3998
	0.3605	2.1529	0.7742	0.9261	1.2305	0.9571
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0036	0.0026	0.0024	0.0009	0.0007	0.0004
	0.0003	0.0010	0.0004	0.0009	0.0025	0.0031
STD. DEVIATIONS	0.0014	0.0013	0.0013	0.0011	0.0011	0.0007
	0.0006	0.0016	0.0008	0.0011	0.0015	0.0012
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0065	0.0041	0.0052	0.0020	0.0009	0.0008
	0.0008	0.0012	0.0006	0.0021	0.0041	0.0051
STD. DEVIATIONS	0.0060	0.0023	0.0064	0.0023	0.0015	0.0017
	0.0016	0.0027	0.0012	0.0043	0.0038	0.0032

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0713	0.0502	0.0379	0.0121	0.0190	0.0078
	0.0048	0.0363	0.0083	0.0180	0.0478	0.0476
STD. DEVIATIONS	0.0604	0.0412	0.0368	0.0227	0.0379	0.0143
	0.0125	0.0774	0.0277	0.0321	0.0441	0.0332

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.289	(0.4719)	1050.46	0.702
EVAPOTRANSPIRATION	30.762	(3.4728)	111665.25	74.575
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.18637	(5.71375)	36976.512	24.69452
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.01875	(0.00614)	68.050	0.04545
AVERAGE HEAD ON TOP OF LAYER 3	0.030	(0.017)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.03335	(0.02804)	121.064	0.08085
CHANGE IN WATER STORAGE	-0.021	(0.8891)	-77.58	-0.052

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.407	5106.9863
DRAINAGE COLLECTED FROM LAYER 2	1.55492	5644.35254
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000926	3.35968
AVERAGE HEAD ON TOP OF LAYER 3	2.016	
MAXIMUM HEAD ON TOP OF LAYER 3	3.128	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	15.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001272	4.61762
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3733

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1026

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

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

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	4.0582	0.2255
2	0.0514	0.2056
3	0.1875	0.7500
4	2.1246	0.1771
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:\2ENGPR~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\2ENGPR~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\2ENGPR~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\2ENGPR~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\2ENGPR~1\HELP3\JC1A2.D10
OUTPUT DATA FILE:            C:\2ENGPR~1\HELP3\JC1A2.OUT

TIME:  16:39     DATE:  12/ 9/2003

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     TITLE:  Johnston County C&DLF - Case 1A2 (5%  - GM)

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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   7
       THICKNESS                     =     18.00   INCHES
       POROSITY                      =      0.4730 VOL/VOL
       FIELD CAPACITY                =      0.2220 VOL/VOL
       WILTING POINT                 =      0.1040 VOL/VOL
       INITIAL SOIL WATER CONTENT    =      0.2329 VOL/VOL
       EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
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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	=	0.2094	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	250.0	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2015	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	75.40	
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	=	4.245	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.726	INCHES

LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.873	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.663	INCHES
TOTAL INITIAL WATER	=	6.663	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

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JC1A2.OUT

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	0.038	0.002	0.011	0.002	0.046	0.010
	0.010	0.118	0.015	0.010	0.019	0.008
STD. DEVIATIONS	0.074	0.008	0.028	0.010	0.128	0.028
	0.035	0.362	0.060	0.035	0.050	0.025
EVAPOTRANSPIRATION						
TOTALS	1.486	1.785	2.998	2.702	3.890	3.635
	3.917	4.149	2.478	1.353	1.268	1.102
STD. DEVIATIONS	0.133	0.256	0.334	0.977	1.037	1.695
	1.460	1.261	1.164	0.428	0.162	0.139
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.0559	1.3206	1.0922	0.3378	0.5470	0.2158
	0.1367	1.0225	0.2303	0.5172	1.3318	1.3732
STD. DEVIATIONS	1.7411	1.0904	1.0593	0.6335	1.0932	0.3974
	0.3616	2.1515	0.7735	0.9252	1.2291	0.9563
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0042	0.0030	0.0025	0.0008	0.0011	0.0005
	0.0003	0.0018	0.0004	0.0010	0.0030	0.0032
STD. DEVIATIONS	0.0029	0.0022	0.0021	0.0013	0.0019	0.0009
	0.0008	0.0034	0.0012	0.0016	0.0024	0.0019
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0069	0.0045	0.0056	0.0023	0.0008	0.0008
	0.0008	0.0011	0.0007	0.0022	0.0043	0.0057
STD. DEVIATIONS	0.0062	0.0025	0.0065	0.0024	0.0013	0.0016
	0.0018	0.0026	0.0013	0.0044	0.0043	0.0031

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0713	0.0502	0.0379	0.0121	0.0190	0.0077
	0.0047	0.0364	0.0083	0.0179	0.0477	0.0476

STD. DEVIATIONS	0.0604	0.0412	0.0367	0.0227	0.0379	0.0142
	0.0125	0.0779	0.0277	0.0321	0.0440	0.0332

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.289	(0.4723)	1050.71	0.702
EVAPOTRANSPIRATION	30.764	(3.4762)	111673.20	74.580
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.18104	(5.71008)	36957.180	24.68161
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.02180	(0.01017)	79.135	0.05285
AVERAGE HEAD ON TOP OF LAYER 3	0.030	(0.017)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.03568	(0.02779)	129.526	0.08650
CHANGE IN WATER STORAGE	-0.021	(0.8884)	-74.95	-0.050

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.409	5115.0962
DRAINAGE COLLECTED FROM LAYER 2	1.55892	5658.87256
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.002106	7.64643
AVERAGE HEAD ON TOP OF LAYER 3	1.972	
MAXIMUM HEAD ON TOP OF LAYER 3	3.135	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	15.6 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001306	4.74062
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3735
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1026

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

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

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	4.0582	0.2255
2	0.0514	0.2056
3	0.0000	0.0000
4	2.1401	0.1783
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                  **
**                                                                              **
**                                                                              **
**********************************************************************************
**********************************************************************************

PRECIPITATION DATA FILE:     C:\2ENGPR~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\2ENGPR~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\2ENGPR~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\2ENGPR~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\2ENGPR~1\HELP3\JC1B1.D10
OUTPUT DATA FILE:            C:\2ENGPR~1\HELP3\JC1B1.OUT

TIME:  16:41     DATE:  12/ 9/2003

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

     TITLE:  Johnston County C&DLF - Case 1B1 (25% - GCL)

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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   7
        THICKNESS                     =     18.00   INCHES
        POROSITY                      =      0.4730 VOL/VOL
        FIELD CAPACITY                =      0.2220 VOL/VOL
        WILTING POINT                 =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.2336 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
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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	=	0.2056	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	25.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

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

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2015	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	76.60	
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	=	4.257	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.726	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.873	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.862	INCHES

TOTAL INITIAL WATER	=	6.862	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

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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	0.052	0.003	0.014	0.004	0.061	0.016
	0.015	0.139	0.021	0.015	0.027	0.011
STD. DEVIATIONS	0.094	0.011	0.034	0.017	0.158	0.036
	0.047	0.410	0.083	0.044	0.061	0.033
EVAPOTRANSPIRATION						
TOTALS	1.492	1.788	3.002	2.705	3.888	3.635
	3.908	4.153	2.484	1.358	1.281	1.109
STD. DEVIATIONS	0.138	0.258	0.336	0.976	1.039	1.700
	1.455	1.261	1.164	0.430	0.155	0.133
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.0365	1.3142	1.0847	0.3363	0.5322	0.2140
	0.1367	1.0015	0.2246	0.5183	1.3119	1.3542
STD. DEVIATIONS	1.7258	1.0895	1.0492	0.6294	1.0625	0.3928
	0.3613	2.1044	0.7510	0.9222	1.2194	0.9438
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0028	0.0021	0.0019	0.0008	0.0005	0.0003
	0.0003	0.0006	0.0003	0.0007	0.0020	0.0025
STD. DEVIATIONS	0.0009	0.0009	0.0010	0.0009	0.0007	0.0005
	0.0005	0.0009	0.0005	0.0009	0.0012	0.0009
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0061	0.0038	0.0049	0.0018	0.0009	0.0008
	0.0007	0.0013	0.0005	0.0019	0.0039	0.0046
STD. DEVIATIONS	0.0062	0.0024	0.0065	0.0021	0.0017	0.0017
	0.0015	0.0025	0.0012	0.0042	0.0038	0.0034

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0150	0.0106	0.0080	0.0026	0.0039	0.0016
	0.0010	0.0074	0.0017	0.0038	0.0100	0.0100
STD. DEVIATIONS	0.0127	0.0087	0.0077	0.0048	0.0078	0.0030
	0.0027	0.0155	0.0057	0.0068	0.0093	0.0069

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.376	(0.5588)	1364.88	0.912
EVAPOTRANSPIRATION	30.801	(3.4722)	111808.57	74.671
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.06503	(5.63419)	36536.043	24.40035
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.01473	(0.00413)	53.456	0.03570
AVERAGE HEAD ON TOP OF LAYER 3	0.006	(0.004)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.03109	(0.02893)	112.859	0.07537
CHANGE IN WATER STORAGE	-0.024	(0.8927)	-86.66	-0.058

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.535	5571.2485
DRAINAGE COLLECTED FROM LAYER 2	1.45619	5285.97803
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000238	0.86253
AVERAGE HEAD ON TOP OF LAYER 3	0.332	
MAXIMUM HEAD ON TOP OF LAYER 3	0.660	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001293	4.69308
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3631

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1026

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

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

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	4.0553	0.2253
2	0.0512	0.2048
3	0.1875	0.7500
4	2.0904	0.1742
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:\2ENGPR~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\2ENGPR~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\2ENGPR~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\2ENGPR~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\2ENGPR~1\HELP3\JC1B2.D10
OUTPUT DATA FILE:            C:\2ENGPR~1\HELP3\JC1B2.OUT

TIME:  16:42     DATE:  12/ 9/2003

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     TITLE:  Johnston County C&DLF - Case 1B2 (25% - GM)

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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   7
        THICKNESS                     =     18.00   INCHES
        POROSITY                      =      0.4730 VOL/VOL
        FIELD CAPACITY                =      0.2220 VOL/VOL
        WILTING POINT                 =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.2336 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
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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	=	0.2056	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	25.00	PERCENT
DRAINAGE LENGTH	=	250.0	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	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2008	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	76.60	
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	=	4.257	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.726	INCHES

LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.873	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.666	INCHES
TOTAL INITIAL WATER	=	6.666	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

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JC1B2.OUT

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	0.053	0.003	0.014	0.004	0.061	0.016
	0.015	0.139	0.021	0.015	0.027	0.011
STD. DEVIATIONS	0.095	0.011	0.034	0.017	0.158	0.036
	0.047	0.410	0.083	0.045	0.061	0.033
EVAPOTRANSPIRATION						
TOTALS	1.493	1.786	3.002	2.704	3.893	3.638
	3.906	4.154	2.484	1.356	1.271	1.109
STD. DEVIATIONS	0.125	0.250	0.337	0.977	1.039	1.697
	1.455	1.264	1.163	0.430	0.159	0.136
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.0373	1.3165	1.0825	0.3354	0.5295	0.2133
	0.1377	1.0005	0.2244	0.5180	1.3217	1.3598
STD. DEVIATIONS	1.7290	1.0884	1.0516	0.6297	1.0599	0.3924
	0.3616	2.1047	0.7508	0.9233	1.2154	0.9545
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0013	0.0009	0.0008	0.0002	0.0003	0.0001
	0.0001	0.0005	0.0001	0.0003	0.0009	0.0010
STD. DEVIATIONS	0.0009	0.0007	0.0006	0.0004	0.0006	0.0003
	0.0002	0.0010	0.0004	0.0005	0.0007	0.0006
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0055	0.0032	0.0045	0.0016	0.0007	0.0007
	0.0007	0.0010	0.0005	0.0018	0.0034	0.0041
STD. DEVIATIONS	0.0064	0.0025	0.0067	0.0021	0.0015	0.0016
	0.0015	0.0023	0.0011	0.0041	0.0040	0.0035

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0150	0.0106	0.0080	0.0025	0.0039	0.0016
	0.0010	0.0074	0.0017	0.0038	0.0100	0.0100

STD. DEVIATIONS	0.0127	0.0087	0.0077	0.0048	0.0078	0.0030
	0.0027	0.0155	0.0057	0.0068	0.0092	0.0070

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.377	(0.5586)	1367.27	0.913
EVAPOTRANSPIRATION	30.797	(3.4810)	111793.45	74.661
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.07666	(5.57970)	36578.270	24.42856
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00654	(0.00298)	23.740	0.01585
AVERAGE HEAD ON TOP OF LAYER 3	0.006	(0.003)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.02759	(0.02985)	100.152	0.06689
CHANGE IN WATER STORAGE	-0.028	(0.8836)	-103.45	-0.069

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	1.535	5571.0869
DRAINAGE COLLECTED FROM LAYER 2	1.45588	5284.85107
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000525	1.90638
AVERAGE HEAD ON TOP OF LAYER 3	0.332	
MAXIMUM HEAD ON TOP OF LAYER 3	0.664	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001302	4.72455
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3631
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1026

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

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

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	4.0565	0.2254
2	0.0512	0.2048
3	0.0000	0.0000
4	1.9882	0.1657
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:\2ENGPR~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\2ENGPR~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\2ENGPR~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\2ENGPR~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\2ENGPR~1\HELP3\JC2A.D10
OUTPUT DATA FILE:            C:\2ENGPR~1\HELP3\JC2A.OUT

TIME:  17: 3     DATE:  12/ 9/2003

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

     TITLE:  Johnston County C&DLF - Case 2A (5%  - 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   7
        THICKNESS                     =      6.00   INCHES
        POROSITY                      =      0.4730 VOL/VOL
        FIELD CAPACITY                =      0.2220 VOL/VOL
        WILTING POINT                 =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.2031 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
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TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2704	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	75.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.218	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.838	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.624	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	12.761	INCHES
TOTAL INITIAL WATER	=	12.761	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	=	6.0	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

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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	0.143	0.002	0.056	0.011	0.172	0.030
	0.047	0.387	0.066	0.061	0.119	0.047
STD. DEVIATIONS	0.301	0.007	0.159	0.049	0.454	0.085
	0.198	1.080	0.287	0.187	0.295	0.184

EVAPOTRANSPIRATION

TOTALS	1.435	1.686	2.485	1.757	2.678	2.770
	3.215	3.213	1.630	1.327	1.324	1.127
STD. DEVIATIONS	0.195	0.297	0.542	1.057	1.067	1.263
	1.162	1.045	0.907	0.532	0.384	0.177

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	1.9158	1.4642	1.3257	0.4773	1.3431	1.0200
	1.0858	1.7956	0.7578	1.1798	1.5853	1.5143
STD. DEVIATIONS	1.6358	1.1661	1.0631	0.6932	1.2585	1.0243
	0.9800	1.8017	0.7720	1.3574	1.4041	0.8960

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	1.9508	1.4353	1.3882	0.7094	1.1861	1.0459
	0.9921	1.7614	0.9873	0.9674	1.5251	1.5316
STD. DEVIATIONS	1.3652	1.0723	0.9755	0.6305	1.1393	0.9345
	0.9687	1.5133	0.7099	1.1018	1.2345	0.9784

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.3490	0.1844	0.1733	0.0524	0.2274	0.1492
	0.1433	0.3083	0.1079	0.1751	0.2679	0.1775
STD. DEVIATIONS	0.4209	0.2062	0.2357	0.1227	0.2899	0.1804
	0.1790	0.4573	0.1469	0.2883	0.2934	0.1497

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	1.140	(1.5801)	4139.77	2.765
EVAPOTRANSPIRATION	24.650	(3.1387)	89478.59	59.758
PERCOLATION/LEAKAGE THROUGH LAYER 2	15.46461	(4.82213)	56136.551	37.49043
AVERAGE HEAD ON TOP OF LAYER 2	0.193	(0.097)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	15.48057	(4.94361)	56194.453	37.52909

CHANGE IN WATER STORAGE	-0.021	(0.9321)	-77.13	-0.052

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	3.232	11730.4443
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.452306	1641.87170
AVERAGE HEAD ON TOP OF LAYER 2	5.935	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.444068	1611.96826
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4730
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.1124	0.1854
2	8.2980	0.4610
3	2.9261	0.2438
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             **
**                                                                              **
**                                                                              **
**********************************************************************************
**********************************************************************************

PRECIPITATION DATA FILE:     C:\2ENGPR~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\2ENGPR~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\2ENGPR~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\2ENGPR~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\2ENGPR~1\HELP3\JC2B.D10
OUTPUT DATA FILE:            C:\2ENGPR~1\HELP3\JC2B.OUT

TIME:  17: 6     DATE:  12/ 9/2003

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

     TITLE:  Johnston County C&DLF - Case 2B (25% - 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   7
        THICKNESS                     =      6.00   INCHES
        POROSITY                      =      0.4730 VOL/VOL
        FIELD CAPACITY                =      0.2220 VOL/VOL
        WILTING POINT                 =      0.1040 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.2031 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
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JC2B.OUT

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2704	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	76.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.219	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.838	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.624	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	12.762	INCHES
TOTAL INITIAL WATER	=	12.762	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	=	6.0	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

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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	0.141	0.002	0.060	0.011	0.175	0.033
	0.052	0.391	0.064	0.062	0.119	0.042
STD. DEVIATIONS	0.302	0.011	0.168	0.049	0.454	0.087
	0.210	1.084	0.273	0.188	0.295	0.169

EVAPOTRANSPIRATION

TOTALS	1.436	1.685	2.488	1.759	2.677	2.785
	3.212	3.212	1.634	1.332	1.325	1.127
STD. DEVIATIONS	0.194	0.295	0.537	1.060	1.065	1.244
	1.155	1.039	0.910	0.533	0.386	0.178

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	1.9160	1.4644	1.3198	0.4760	1.3455	1.0056
	1.0762	1.7934	0.7548	1.1811	1.5793	1.5204
STD. DEVIATIONS	1.6452	1.1668	1.0594	0.6903	1.2588	1.0260
	0.9574	1.8003	0.7699	1.3611	1.4030	0.8991

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	1.9536	1.4342	1.3813	0.7091	1.1871	1.0420
	0.9735	1.7567	0.9865	0.9676	1.5201	1.5368
STD. DEVIATIONS	1.3711	1.0755	0.9733	0.6285	1.1396	0.9328
	0.9240	1.5120	0.7103	1.1026	1.2324	0.9802

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.3477	0.1854	0.1748	0.0518	0.2261	0.1466
	0.1400	0.3133	0.1090	0.1733	0.2664	0.1756
STD. DEVIATIONS	0.4166	0.2055	0.2379	0.1221	0.2896	0.1793
	0.1698	0.4630	0.1475	0.2860	0.2932	0.1483

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	1.151	(1.5839)	4179.93	2.792
EVAPOTRANSPIRATION	24.671	(3.1364)	89555.40	59.809
PERCOLATION/LEAKAGE THROUGH LAYER 2	15.43242	(4.80567)	56019.699	37.41239
AVERAGE HEAD ON TOP OF LAYER 2	0.192	(0.098)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	15.44844	(4.93023)	56077.832	37.45121

CHANGE IN WATER STORAGE	-0.021	(0.9294)	-77.45	-0.052

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	3.244	11775.3066
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.452074	1641.02734
AVERAGE HEAD ON TOP OF LAYER 2	5.923	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.443861	1611.21484
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4730
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.1121	0.1854
2	8.2980	0.4610
3	2.9248	0.2437
SNOW WATER	0.000	

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PROJECT Johnston County - C&D Landfill Vertical Expn.
SUBJECT Final Cover Drainage Layer Analysis

SHEET 1 OF 3
JOB NO. JOHNSTON-21
DATE 12/9/03
COMPUTED BY PKS
CHECKED BY

Objective To evaluate the required transmissivity for the drainage geocomposite placed in the final cover system.

References Richardson, G.N., Giroud, J.P., and Zhao, A. (2001), Design Manual of Lateral Drainage Systems for Landfills, Tenax Corp., Baltimore.

Analysis

Step 1:

Determine the required transmissivity (θ_{reqd}) of the drainage geocomposite based on the following equation:

$$\theta_{reqd} = \frac{RD_{dc} q_n L}{\sin \beta} \qquad (m^3/m/sec)$$

Where:

RD_{dc} = Drainage Geocomposite Reduction Factor (See Note 1)
q_n = Fluid Input Rate/Impingement Rate (m/s) (See Note 2)
L = Flow Length/Drain Spacing (m)
β = Slope Angle of Final Cover (degrees).

Notes:

1. Based on the recommendations of Richardson, Giroud, & Zhao, use $FS_{dc} = 6$. This accounts for an overall factor of safety of 2, plus a factor of safety of 3 for long-term intrusion, creep, and clogging concerns.

2. Typically the impingement into the drainage geocomposite is determined by the **lessor** of:

   a. Permeability of the Overlying Vegetative Soil Layer(k_{veg}) or
   b. Design Rainfall.

   Per Richardson,Giroud, & Zhao, use $q_n = k_{veg}$ except in arid/semi-arid areas.

Step 2:

Determine the required transmissivity test parameters:

- Normal Stress (Cover Thickness x Unit Weight of Cover Soil) and
- Hydraulic Gradient (Equals Slope of Cover System).

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

Step 3:

Calculate the required total flow capacity (Q) of the drain based on the following equation:

$$Q = q_n A \qquad \text{(cfs)}$$

Where: q_n = Impingement (ft/s)
A = Total Area Served by the Drain (= L x DL) (ft^2)
DL = Length of Drain (ft).

Step 4:

After finding Q for each drain, the designer shall select the appropriate type and size of drain.

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SHEET: 3 /3
JOB #: JOHNSTON-21
DATE: 12/9/03
BY: PKS
CHKD BY:

Johnston County C&DLF Vertical Expansion
Final Cover Drainage Layer Analysis

Input Parameters: (User Input)

Side Slope Angle (Beta):		14.0	degrees	
Final Cover:	Thickness:	1.5	ft	
	Unit Weight:	110	pcf	
Impingement (q_n):		0.0001	cm/sec	(= Permeability of Vegetative Soil Layer)
Drain Spacing (L):		250	ft	
Desired Reduction Factor (RD_{dc}):		6		(Per Richardson, Giroud, & Zhao Recommendations)
Drain Length (DL):		500	ft	

Note: Spreadsheet Converts Units as Required.

Transmissivity Requirements:

USE 2×10^{-3}

Determine Minimum Transmissivity:

$Theta_{min}$ = 1.9E-03 $m^3/m/sec$ = 9.1 gpm/ft

Determine Transmissivity Test Parameters:

Min. Normal Stress = 165.0 psf

Hydraulic Gradient = 0.25

Determine Required Drain Capacity:

Calculate Required Total Flow Capacity:

Q = 0.4 cfs

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PROJECT Johnston County - C&D Landfill Vertical Expn.

SUBJECT Final Cover Veneer Stability Evaluation

SHEET 1 OF 2
JOB NO. JOHNSTON-21
DATE 12/9/03
COMPUTED BY PKS
CHECKED BY

Objective To evaluate the stability of the final cover veneer against sliding.

Reference Matasovic, N. (1991), "Selection of Method for Seismic Slope Stability Analysis," Proc. 2nd International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, St. Louis, Vol. 2, pp.1057-1062.

Requirements FS_{min}(Static) = 1.5

FS_{min}(Dynamic) = 1.0 (If Applicable)

Analysis Treat the final cover as an infinite slope and use the following equation (Matasovic, 1991):

$$FS = \frac{c/(\gamma \cdot z \cdot \cos^2\beta) + \tan\varphi[1 - u/(\gamma \cdot z)] - k_s \cdot \tan\beta \cdot \tan\varphi}{k_s + \tan\beta}$$

Where: FS = Factor of Safety
K_s = Seismic Coefficient (= 0 for Static Stability)
γ = Unit Weight of Slope Material(s)
c = Cohesion
φ = Interface Friction Angle of Assumed Failure Surface (degrees)
u = Pore Pressure (above geomembrane) or LFG Pressure (below geomembrane)
$u = \gamma_w(z - d_w)$ (For Pore Pressure)*
γ_w = Unit Weight of Water
z = Depth to Failure Surface
d_w = Depth to Seepage Surface (= z if slope is Dry)
β = Slope Angle of Cover (degrees).

*Note: Based on an allowable LFG pressure of 6 inch-w.c. (= 31.2 psf), the use of a depth to seepage of 1.5 feet or less (for evaluation of interfaces above the geomembrane) will satisfy the evaluation for LFG pressure against the bottom of the geomembrane as well.

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Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
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ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2/2
JOB #: JOHNSTON-21
DATE: 12/9/03
BY: PKS
CHKD BY:

Johnston County C&DLF Vertical Expansion
Final Cover Veneer Stability Evaluation

Input Parameters: (User Input)

Side Slope Angle (Beta): 14 degrees

Final Cover:
- Thickness (z): 1.5 ft
- Unit Weight: 110 pcf
- Cohesion: 0 psf ← CONSERVATIVE
- Water Depth: 1 ft (= z if Slope is Dry)

Seismic Coefficient (ks): 0 Static FS

Calculate Static FS Against Sliding:

Interface Fric. Angle	Resisting Force	Driving Force	FS slide	Comment
23	0.34	0.25	1.38	NO GOOD
24	0.36	0.25	1.45	NO GOOD
25	0.38	0.25	1.52	OK ← Interfaces ≥ 25° OK.
26	0.40	0.25	1.59	OK
27	0.41	0.25	1.66	OK
28	0.43	0.25	1.73	OK

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Technical Specifications

Johnston County
C&D Landfill Vertical Expansion

Prepared for:
Johnston County Department of Public Utilities
Smithfield, North Carolina

December 2003

G.N. Richardson & Associates, Inc.
Engineering and Geological Services
14 N. Boylan Avenue
Raleigh, North Carolina 27603

JOHNSTON COUNTY
C&D LANDFILL VERTICAL EXPANSION

TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

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 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
Excavation	02222
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 2922	Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
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.

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 SM, SP, SC, ML, MH, CL-ML, CL or CH (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.

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 and appurtenant structures.

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 (ASTM D 3017)[3]	Maximum Lift Thickness (Compacted) (inches)
Embankment	95	± 4% of Optimum Moisture Content	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 2922, ASTM D 1556, ASTM D 2167, or ASTM D 2937.
3. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959.

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 the landfill gas system, as a component of the Geonet Drainage Media, and 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
Geonet Drainage Media	02712
Landfill Gas Vents	13250
CQA Manual	Attached

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.

4. Quality Assurance:

Quality Assurance during installation of Geotextiles 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 Geotextile shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. The Type GT-S Geotextile shall be a woven, nonwoven spunbonded, or nonwoven needlepunched synthetic fabric consisting of polyester or polypropylene manufactured in a manner approved by the Engineer. Note that

Type GT-S Geotextile used as a component of the Geonet Drainage Media shall be a nonwoven fabric.

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

C. SUBMITTALS

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 one copy of 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 (4" x 6") 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. Quality Control Certificates: For Geotextiles delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of each type of Geotextile supplied. 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.

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. Failing CQA Material Control Tests:

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

3. Installation of Geotextiles:

a. The surface receiving the Geotextiles shall be prepared to a relatively smooth condition, free of obstructions, excessive depressions, debris, and very soft or loose pockets of soil. This surface shall be approved by the CQA 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 CQA 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 CQA Engineer. Geotextiles uplifted by wind may be reused upon approval by the CQA Engineer.

4. Seams:

a. All Geotextile seams shall be sewn. On slopes greater than 10 percent, all seams shall be oriented parallel to (in the direction of) the slope unless otherwise approved by the Engineer.

b. 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. All seams must be approved by the CQA Engineer.

c. Alternately, the Contractor may overlap or heat bond adjacent panels with methods approved by the Engineer.

5. Repair Procedures:

a. Any Geotextile that is torn or punctured 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 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 so as not to shift during cover placement.

b. Slopes Less Than or Equal to 10 Percent: Damaged areas of a size exceeding 10 percent of the roll width shall be removed and replaced across the entire roll width with new material. Damaged areas of a size less than 10 percent of the roll width may be patched.

c. Slopes Greater Than 10 Percent: Geotextile panels which require repair shall be removed and replaced with new material. Replacement material shall be sewn as previously described in this specification.

6. Cover Placement:

Placement of cover over Geotextiles shall be performed in a manner as to ensure that the Geotextiles 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] NW[2] (See Note 5)
Mass per Unit Area (Unit Weight)	ASTM D 5261	oz/yd^2	N/A 6 (See Note 5)
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	70
Strength Class[4]	AASHTO M 288	Class	2
Grab Tensile Strength	ASTM D 4632	lbs	160 (NW) 250 (W)
Grab Tensile Elongation	ASTM D 4632	%	$\geq$ 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 formed exclusively with slit film fibers are not acceptable.
4. AASHTO M 288 criteria includes the above listed requirements for: Grab Tensile Strength, Grab Tensile Elongation, Puncture Resistance, Trapezoidal Tear Strength, and Burst Strength.
5. Required for Geonet Drainage Media.

TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Mass per Unit Area (Unit Weight)	ASTM D 5261	200,000 ft^2
Ultraviolet Resistance (500 hrs)	ASTM D 4355	Periodic
Grab Tensile Strength	ASTM D 4632	200,000 ft^2
Grab Tensile Elongation	ASTM D 4632	200,000 ft^2
Burst Strength (Diaphragm Methods)	ASTM D 3786	200,000 ft^2
Apparent Opening Size (AOS)	ASTM D 4751	Periodic
Permittivity	ASTM D 4491	Periodic
Puncture Resistance	ASTM D 4833	200,000 ft^2
Trapezoidal Tear Strength	ASTM D 4533	200,000 ft^2

END OF SECTION

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. This section includes the topsoil to be placed as the upper 6 inches of the VSL.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of the VSL (including topsoil) 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
Geonet Drainage Media	02712
Geosynthetic Clay Liner	02776
LLDPE Geomembrane	02778
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 422	Standard Test Method for Particle Size Analysis of Soils.
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

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 shall be classified according to the Unified Soil Classification System (USCS) as SC or CL (ASTM D 2488) and shall have no more than 15% non-plastic fines (ASTM D 422). Alternatives to these requirements must be approved in advance by the Engineer.

2. Select soil fill materials shall be reasonably free of gypsum, ferrous, and/or calcareous concretions and nodules, refuse, roots, or other deleterious substances.

3. Continuous and repeated visual inspection of the materials being used will be performed by the Contractor to ensure proper soils are being used. In addition, the CQA Engineer shall make frequent inspections of the placement operations and materials, and will consult with the Engineer.

4. 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.

5. Topsoil: The upper 6 inches of VSL shall be natural or blended soil material capable of supporting the growth of vegetative cover. Topsoil shall contain a minimum of 2% by weight of organics evenly blended into the material in order to support the 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.

2. Survey Results:

   After completion of a segment of VSL, survey results shall be submitted for review prior to VSL acceptance.

D. CONSTRUCTION

1. The VSL is placed directly over geosynthetics and/or piping; thus, extreme caution shall be exercised by the Contractor to prevent damage to these materials.

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

3. VSL shall be placed over geosynthetics only after areas have been released by the Geosynthetics Installer and the CQA Engineer. VSL shall be placed as specified below:

   a. The VSL, including topsoil, shall be placed and spread using low ground pressure (less than 6 psi) tracked equipment. The CQA Engineer shall approve the equipment used to place the VSL.

   b. Tracked equipment used to place VSL shall operate on at least 1 foot of VSL overlying geosynthetics and/or piping. Excessive turning of tracked equipment on the VSL will not be permitted.

   c. On side slopes, place VSL from the bottom up unless otherwise approved by the Engineer. No material shall be dumped down a slope.

   d. VSL shall be placed 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.

4. The VSL shall be spread in a manner that minimizes development of wrinkles in the underlying geosynthetics. Any portion of the underlying geosynthetics that develops excessive wrinkles or crimp shall be repaired by the Geosynthetics Installer at no expense to the Owner.

   a. VSL shall be placed before noon or at other times when the ambient air temperature is not more than 75°F to minimize wrinkling of underlying geosynthetics unless otherwise approved by the Engineer.

   b. If during spreading, excessive wrinkles develop, the Contractor shall adjust placement and spreading methods, or cease until the underlying geosynthetics cool and wrinkles decrease in size.

   c. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and spreading methods or underlying geosynthetics that become crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

5. Stockpiling of VSL on the final cover shall be subject to advance approval by the Engineer. Any hauling equipment (dump trucks, etc.) operating over geosynthetics shall have a minimum of 3 feet of separation between the vehicle wheels and the Geomembrane.

6. The CQA Engineer may require removal of VSL and/or other underlying layers at the Contractor's sole expense to allow examination of the underlying geosynthetics and/or piping. Any damage to underlying layers or excessive wrinkling or crimping during placement of the VSL shall be repaired in accordance with the applicable section of these Specifications at the Contractor's sole expense.

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

8. Surveying:

After completion of a segment of VSL, the VSL shall be surveyed on 100 foot centers and at slope breaks (including all tops and toes of slope, points of grade change, etc.) to ensure:

a. The specified thickness has been achieved.

b. The top of the VSL slopes at grades specified on the Contract Drawings; and

c. VSL placed more than 0.15 feet beyond the limits of the lines and grades as shown on the Contract Drawings will not be accepted and must be removed at the Contractor's sole expense if required by the Engineer.

This work shall be performed at the Contractor's cost by a surveyor registered in the State of North Carolina.

END OF SECTION

SECTION 02270

EROSION AND SEDIMENTATION CONTROL

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

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of and maintain Erosion and Sedimentation Control facilities and other construction 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
Rip Rap	02271
Rolled Erosion Control Products	02275
Storm Water Systems	02720
Revegetation	02930
Concrete Work	03310

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 Ditches, Swales, and Drainage Channels:

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

2. 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 3 feet long "U" or "T"-type steel or wood posts.

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.

3. Geotextiles:

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

4. Filter Berms:

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

5. Down Pipes:

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

6. Rip Rap:

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

7. 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.

8. Other Work:

In addition to the erosion 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.

9. Temporary and Permanent Ground Cover:

The Contractor shall provide temporary or permanent ground cover adequate to restrain erosion on erodible slopes or other areas within 15 working days or 30 calendar days (whichever is shorter) following completion of any phase of grading.

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 Control Devices:

a. All erosion control structures 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 control devices may need to be adjusted on several occasions to reflect the current phase of construction.

c. Erosion control devices shall be established prior to the work in a given area. Where such practice is not feasible, the erosion control device(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 devices required for the control of erosion. The Contractor shall develop and implement such additional techniques as may be required to minimize erosion and off-site sedimentation.

e. The location and extent of erosion control devices 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. Maintenance of Erosion Control Devices:

a. The Contractor shall furnish the labor, material, and equipment required for maintenance of all erosion control devices. Maintenance shall be scheduled as required for a particular device to maintain the removal efficiency and intent of the device.

b. All erosion control devices shall be inspected immediately after each significant rainfall event, and appropriate maintenance conducted.

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

(1) The removal and satisfactory disposal of trapped sediments from basins or silt barriers;

(2) Replacement of filter fabrics used for silt fences upon loss of specified 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 sediment basins that accept or will accept stormwater flow and or silt accumulation from all areas within the Contractor's limits of construction.

e. Sediments removed from erosion control devices shall be disposed of in locations that will not result in off-site sedimentation as approved by the Engineer.

f. All erosion control structures 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. Seeding:

Seeding 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	%	15 (Max.)
Trapezoidal Tear Strength[2]	ASTM D 4533	lbs	50 x 50
Burst Strength	ASTM D 3786	psi	265
Puncture Resistance	ASTM D 4833	lbs	55
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	80
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	20 (Max.)/40 (Min.)
Permittivity	ASTM D 4491	sec^{-1}	0.20

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 matting (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 1777	Standard Test Method for Thickness of Textile Materials.
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
ASTM D 5035	Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method).

ASTM D 5261 Standard Test Method for Measuring Mass per Unit Area of 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 RECP shall identify the length, width, product name, and name of Manufacturer.

2. Erosion Control Blanket (ECB) (Single Net):

ECB (single net) shall consist of a machine-produced mat of curled wood excelsior. At least 80 percent of the individual excelsior fibers shall be 6 inches or more in length. The excelsior fibers shall be evenly distributed over the entire blanket. The top side of the blanket shall be covered with a photodegradable extruded plastic or woven biodegradable mesh. The mesh shall be attached to the curled wood excelsior with degradable thread. ECB shall also conform to the properties listed in Table 1 of this section. ECB shall be CURLEX I, as manufactured by American Excelsior Company, or approved equal.

3. Turf Reinforcement Matting (TRM):

TRM shall consist of a machine-produced mat of mechanically or melt-bonded polymer nettings, monofilaments, or fibers entangled to form a strong, dimensionally stable, three dimensional permanent vegetation reinforcement structure. The mat shall be crush-resistant, pliable, water-permeable, and highly resistant to chemical and environmental degradation. TRM shall also conform to the properties listed in Table 1 of this section. TRM shall be LANDLOK TRM 435, as manufactured by Synthetic Industries, or approved equal.

4. Anchors: Anchors for RECPs shall consist of machine made staples of No. 8 gage 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 one copy of 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. 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 Manufacturer's 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 Manufacturer's 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) (Single Net)			
Mass per Unit Area (Unit Weight)	ASTM D 5261	lbs/yd^2	0.975 ± 10%
Aperture Size - Mesh	Measured	inches	1.0 x 1.0 (max.)
Maximum Permissible Shear Stress (Un-Vegetated)	-----	lb/ft^2	1.55
Turf Reinforcement Matting (TRM)			
Mass per Unit Area (Unit Weight)	ASTM D 5261	oz/yd^2	8
Thickness	ASTM D 1777	inches	0.35
Tensile Strength[2]	ASTM D 5035	lbs/ft	145 x 110
Tensile Elongation	ASTM D 5035	%	50 (max.)
Porosity	Calculated	%	90
Resiliency	ASTM D 1777	%	80
UV Stability	ASTM D 4355	%	80
Maximum Permissible Velocity (Long-Term Vegetated)	-----	ft/sec	8
Maximum Permissible Shear Stress (Long-Term Vegetated)	-----	lb/ft^2	3

Notes:

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

END OF SECTION

SECTION 02712

GEONET DRAINAGE MEDIA

Geonet Drainage Media (GDM): The Geonet Drainage Media consists of a layer of Geonet with a Type GT-S Geotextile bonded to each surface. The purpose of the GDM is to rapidly transmit side slope flow to collection pipes. Thus, it is important that this layer remain hydraulically connected and clog-free.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of GDM, 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
Vegetative Soil Layer	02258
Geosynthetic Clay Liner	02776
LLDPE Geomembrane	02778
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 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 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 Assurance:

Quality Assurance during installation of GDM 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 GDM shall identify the length, width, lot and roll numbers, and name of Manufacturer.

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

3. A Type GT-S Geotextile shall be heat bonded to both sides of the Geonet. Heat bonding shall be performed by the Manufacturer prior to shipping to the site. The Type GT-S Geotextile shall be a nonwoven needlepunched synthetic fabric meeting the property requirements of Section 02240, Geotextiles, of these Specifications.

4. The Geonet shall contain UV inhibitors to prevent ultraviolet light degradation.

5. Physical properties of the GDM shall be as shown in Table 1 of this section.

C. SUBMITTALS

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 one copy of a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the GDM attesting that the GDM meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample (4" x 6") of the GDM 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. Quality Control Certificates: For GDM delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of GDM. 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.

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

2. Failing CQA Material Control Tests:

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

3. Installation:

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

b. The GDM shall be placed only on Geomembrane that has been approved by the Geomembrane Installer and accepted by the CQA Engineer.

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

d. The Contractor shall provide temporary anchorage of the GDM at the top of perimeter and interior berms during installation 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.

e. Adjacent rolls of GDM shall be overlapped a distance of at least 3 inches and secured using polyethylene ties. For GDM placed on slopes, the ties shall be placed every 5 feet. For GDM placed on the facility floor, tie spacing shall be every 10 feet.

The overlying Type GT-S Geotextile, where applicable, shall extend at least 6 inches past the geonet seam and shall be permanently bonded to the Type GT-S Geotextile of the adjacent rolls by heat bonding or sewing as approved by the Engineer.

All seams constructed on sloped surfaces $\geq$ 6H:1V or within 10 feet of the toe of a side slope 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 shall be staggered a minimum of 5 feet between adjacent rolls and shall have ties placed every 2 feet.

f. Any GDM that is torn, crushed, or punctured shall be repaired or replaced 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 failed area and shall overlap the existing material a minimum of 12 inches from any

point of the rupture. The patch shall be connected to the Geonet using polyethylene ties at a 6 inch spacing.

g. Where applicable, the Contractor shall remove debris, including sediment to the degree possible, from the sump areas prior to placement of the GDM. The sump areas shall be approved by the CQA Engineer prior to GDM placement.

4. Cover Placement:

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

TABLE 1: REQUIRED GEONET DRAINAGE MEDIA PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE
Thickness (geonet only)	ASTM D 5199	inches	0.25
Density (geonet only)	ASTM D 1505	g/cm^3	0.94
Ply Adhesion	ASTM D 413/ GRI GC7	lb/inch	2.0 Typ. 1.0 Min. Avg.
Transmissivity: (Final Cover)	ASTM D 4716	$m^3/m/sec$	2.0×10^{-3} (See Note 1)
Interface Shear Strength (Peak)[2, 3]	ASTM D 5321 ASTM D 6243 (GCL)	psf	70 psf (Load = 100 psf) 125 psf (200 psf) 250 psf (400 psf)

TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Thickness (geonet only)	ASTM D 5199	50,000 ft^2
Density (geonet only)	ASTM D 1505	50,000 ft^2
Grab Tensile Strength (geotextile only)	ASTM D 4632	200,000 ft^2
Puncture Resistance (geotextile only)	ASTM D 4833	200,000 ft^2
Apparent Opening Size (AOS) (geotextile only)	ASTM D 4751	600,000 ft^2
Ply Adhesion	ASTM D 413/ GRI GC7	100,000 ft^2
Transmissivity	ASTM D 4716	100,000 ft^2 (See Note 4)
Interface Shear Strength	ASTM D 5321 ASTM D 6243 (GCL)	(See Note 3)

Notes:

1. Final Cover:
   Conduct test for transmissivity at a normal compressive load of 500 psf and at a hydraulic gradient of 0.25 after a seating period of at least 1 hour (Optionally run test at 250 psf for 24 hours). Boundary conditions are soil (sand) interface on the upper Type GT-S Geotextile and GCL or textured LLDPE geomembrane against the lower Type GT-S Geotextile.
2. 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. GCL or Textured LLDPE-GM (30 mil) against existing cover soils (intermediate cover);
   B. Geonet Drainage Media against GCL or textured LLDPE-GM (30 mil); and
   C. Vegetative Soil Layer against Geonet Drainage Media.

   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.

3. GDM shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
4. 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.

END OF SECTION

SECTION 02720

STORM WATER SYSTEMS

Storm Water Systems: Storm Water Systems shall include all piping, pipe fittings, flared end sections, 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
Excavation	02222
Embankment	02223
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 the reinforced concrete pipe shall have bell and spigot ends with flexible preformed plastic gaskets.

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 CQA 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 applicable sections of the Concrete Pipe Handbook as published by the American Concrete Pipe Association.

END OF SECTION

SECTION 02776

GEOSYNTHETIC CLAY LINER (GCL)

Geosynthetic Clay Liner (GCL): The GCL is used as a 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
Vegetative Soil Layer	02258
Geonet Drainage Media	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 1777	Standard Test Method for Thickness of Textile Materials.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
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 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.

4. Quality Assurance:

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

5. 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.

6. Installer Qualifications:

The GCL Installer shall have installed a minimum of 500,000 square feet of GCL in the past two (2) years in similar landfill installations.

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, stitched or needle-punched together for reinforcement. 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. 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 one copy of 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. The Contractor shall also submit a sample (4" x 6") 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 Drawings, Procedures, and Schedules:

Submit installation (shop) drawings, procedures, and a schedule for carrying out the work. Procedures addressed by the Contractor shall include but not be limited to material unloading, storage, installation, repair, and protection to be provided in the event of rain. A schedule showing the order of placement, location of panels, seams, and penetrations shall be submitted for the Engineer's review. Submit drawings showing the panel layout, seams, and associated details including pipe penetrations. Following review, these drawings will be used for installation of the GCL. Any deviations from these 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.

g. 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.

c. Record Information: Record information shall include but not be limited to: drawings showing the location of all areas covered by GCL.

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. 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.

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

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

d. 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 sloped surfaces $\geq$ 6H:1V shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer.

e. All vertical panels placed on side slope surfaces shall extend a minimum of 5 feet inward from the toe of slope or edge of trench.

f. The GCL shall not be placed in standing water or while raining. Any material that becomes hydrated shall be removed and replaced at Contractor expense.

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.

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 or punctured 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 failed areas and shall overlap the existing GCL a minimum of 12 inches from any point of the rupture.

j. GCL shall be covered with the overlying Geonet Drainage Media and Vegetative Soil Layer or otherwise protected from hydration due to rainfall (i.e. temporary tarps, scrap geomembrane) 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 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[1]
Hydraulic Conductivity	ASTM D 5084/D 5887	cm/s	5×10^{-9}
Bentonite Content	ASTM D 5993	psf	0.75 (@ 0% moisture)
Bentonite Swell Index	ASTM D 5890	mL/2g	24
Thickness	ASTM D 1777	inches	0.20
Grab Tensile Strength	ASTM D 4632	lbs	150
Peel Strength[2]	ASTM D 6496	lbs	25
Minimum Shear Strength[3] (Hydrated) (Peak)	ASTM D 6243	psf	500
Interface Shear Strength (Hydrated) (Peak)[4, 5]	ASTM D 6243	psf	70 psf (Load = 100 psf) 125 psf (200 psf) 250 psf (400 psf)

TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Hydraulic Conductivity	ASTM D 5084/D 5887	Weekly
Bentonite Content	ASTM D 5993	50,000 ft^2
Bentonite Swell Index	ASTM D 5890	100,000 lbs
Thickness	ASTM D 1777	Periodic
Grab Tensile Strength	ASTM D 4632	200,000 ft^2
Peel Strength[2]	ASTM D 6496	50,000 ft^2
Minimum Shear Strength[3] (Hydrated)	ASTM D 6243	Periodic
Interface Shear Strength	ASTM D 6243	(See Note 4)

Notes:

1. Minimum Average Roll Values (MARV)
2. Based on a 4 inch wide sample/4 inch grip width. Alternatively, a value of 15 lbs is acceptable based on a 4 inch wide sample/1 inch grip width. Also, a value of 35 lbs is acceptable using ASTM D 4632 in lieu of ASTM D 6496.
3. Peak value measured at a normal load of 200 psf.
4. 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. GCL or Textured LLDPE-GM (30 mil) against existing cover soils (intermediate cover);
   B. Geonet Drainage Media against GCL or textured LLDPE-GM (30 mil); and
   C. Vegetative Soil Layer against Geonet Drainage Media.

   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.

5. GCL shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.

END OF SECTION

SECTION 02778

LLDPE GEOMEMBRANE

LLDPE Geomembrane (LLDPE-GM): The LLDPE Geomembrane serves as a 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
Geonet Drainage Media	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 638	Standard Test Method for Tensile Properties of Plastics.
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.
GRI GM12	Asperity Measurement of Textured Geomembranes Using a Depth Gage.

4. Quality Control:

The Geomembrane Installer will perform and document nondestructive and destructive Quality Control tests during installation of LLDPE-GM as described in the accompanying Project CQA Manual.

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 welding machine operators shall have shown proven performance on previous LLDPE-GM installations. All welding machine operators shall perform a demonstration of their welding technique and a test of the welds which they have performed prior to any welding on the project.

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-welded 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 prior to the Contract award.

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. Resin Properties: The resin shall be linear low density polyethylene (LLDPE) and shall be new, first-quality, compounded and manufactured specifically for producing LLDPE-GM. The resin shall not consist of mixed resin types. Recycled material reworked from the manufacturing process shall not exceed 5% by weight.

b. LLDPE-GM Sheet Properties: The LLDPE-GM sheeting shall be manufactured to meet the following requirements:

(1) Provide finished product free from holes, pin holes, bubbles, blisters, excessive gels, undispersed resins and/or carbon black, contamination by foreign matter, and nicks or cuts on edges.

(2) Physical properties of the LLDPE-GM shall be as shown in Table 1 of this section.

c. 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 welding 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 and not by lamination or embossing methods. 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. Physical properties of textured LLDPE-GM 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 LLDPE-GM installation the Contractor shall submit the following:

a. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit one copy of 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 (6" x 8") 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 welders 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 Drawings, Procedures, and Schedules:

(1) Submit installation (shop) drawings, procedures, and a schedule for carrying out the work. Shop drawings shall have LLDPE-GM sheet layout with proposed size, number, position, and sequence of placing of 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. Following review, these drawings will be used for installation of the LLDPE-GM. Prior to deviations from these drawings during construction, revised drawings must be submitted to and reviewed by the Engineer and CQA Engineer.

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

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 be as shown in Table 2 of this section.

g. 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: drawings showing the true panel dimensions; location and coordinates of all seams; panels with roll numbers; repairs; patches; destructive test locations; and pipe penetrations and other appurtenances. This information shall be accompanied by electronic data files of both plots and point listings which show X, Y, and Z and description for each point.

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 40° F or above 100° F unless otherwise authorized, in writing, by the Engineer. 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 will 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 welding. The area to be welded shall be cleaned and prepared in accordance with the Manufacturer's recommendations.

b. Single or double track hot wedge fusion welds shall be used for straight seams.

c. Extrusion welds shall be used for cross seam tees, patches, repairs, and penetration boots. To limit overgrinding, the amount of grinding exposed after an extrusion seam is completed should be less than ¼ inch.

d. The welding 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 weld.

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 welded together.

f. All fusion welded "T" seams (i.e., the result of panels placed perpendicular to each other) shall be double welded where possible. The extrusion process shall be used for the second weld.

g. All extrudate shall be free of dirt, dry, and protected from damage.

h. If an extrusion welder 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.

i. 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 sloped surfaces $\geq$ 6H:1V shall be

vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer.

j. All vertical panels placed on side slope surfaces shall extend a minimum of 5 feet inward from the toe of slope or edge of trench.

k. All end seams shall be staggered a minimum of 5 feet in length between contiguous panels.

l. To prevent moisture buildup during fusion welding, 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 shall extend to the full extent of the anchor trench.

o. All seams (including repairs) shall meet seam strength requirements specified in Table 3 of this section.

p. 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 will be extrusion seamed to the underlying LLDPE-GM. This method should be used to repair lengths of extrusion or fusion 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 will 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 will be approved in advance of the specific repair by the CQA Engineer; and

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

8. 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
			30 mil Textured[1]
Thickness[2]	ASTM D 5994	mils	30
Asperity Height (typ.)	GRI GM12	mils	20 (See Note 3)
Density	ASTM D 1505/D 792	g/cm^3	$\leq$ 0.939
Carbon Black Content	ASTM D 1603	%	2.0-3.0
Carbon Black Dispersion	ASTM D 5596	category	See Note 4
Tensile Properties:	ASTM D 638 Type IV (See Note 5)		
Tensile Strength at Break		lb/inch	$\geq$ 45
Elongation at Break		%	$\geq$ 250
Tear Resistance	ASTM D 1004	lbs.	$\geq$ 16
Interface Shear Strength (Peak)[6]	ASTM D 5321	psf	70 psf (Load = 100 psf) 125 psf (200 psf) 250 psf (400 psf)

Notes:

1. Textured LLDPE-GM is textured on both sides.
2. For smooth LLDPE-GM, the lowest individual thickness of 10 values = -10%. For textured LLDPE-GM, the lowest individual thickness for 8 out of 10 values = -10%; the lowest individual thickness of any of the 10 values = -15%.
3. Or as otherwise required to satisfy interface shear strength criteria.
4. Carbon black dispersion for 10 different views:
   - minimum 8 of 10 in Categories 1 or 2
   - all 10 in Categories 1, 2, or 3.
5. Break elongation calculated with a gauge length of 2.0 inches.
6. Textured LLDPE-GM shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.

TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Thickness	ASTM D 5199/D 5994	Every Roll
Asperity Height	GRI GM12	Every 2nd Roll (See Note 1)
Density	ASTM D 1505/D 792	200,000 lb
Carbon Black Content	ASTM D 1603	45,000 lb
Carbon Black Dispersion	ASTM D 5596	45,000 lb
Tensile Properties	ASTM D 638 Type IV	20,000 lb
Tear Resistance	ASTM D 1004	45,000 lb
Interface Shear Strength	ASTM D 5321	(See Note 2)

Notes:

1. Alternate the measurement side for double sided textured sheet.
2. 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. GCL or Textured LLDPE-GM (30 mil) against existing cover soils (intermediate cover);
   B. Geonet Drainage Media against GCL or textured LLDPE-GM (30 mil); and
   C. Vegetative Soil Layer against Geonet Drainage Media.

   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	MINIMUM VALUE
		30 mil
Bonded Shear Strength	ASTM D 6392	40 lb/inch and FTB[1]
Seam Peel Adhesion	ASTM D 6392	36 lb/inch and FTB[1]

Notes:

1. FTB = Film-Tear-Bond = Tearing in the membrane itself before ply separation of the seam.

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
Embankment	02223
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 Section D.4 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 10-20-10 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	Kentucky 31 Tall Fescue Pensacola Bahiagrass Sericea Lespedeza[3] Kobe Lespedeza Seasonal Nurse Crop[2]	80 lbs/acre 50 lbs/acre 30 lbs/acre 10 lbs/acre See Note 2
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.
2. Use seasonal nurse crop in accordance with seeding dates as stated below:

April 15 - August 15	10 lbs/acre German Millet or 15 lbs/acre Sudangrass
August 16 - April 14	25 lbs/acre Rye (grain).

3. From September 1 - March 1, use unscarified sericea seed.

END OF SECTION

SECTION 13250

LANDFILL GAS VENTS

Landfill Gas Vents: Landfill Gas Vents are installed under the landfill cover in order to vent landfill gases, particularly methane, which builds up due to the decomposition of waste.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Landfill Gas Vents 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
Excavation	02222
Geotextiles	02240

3. Reference Standards:

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

ASTM D 1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
NCDOT	Standard Specifications for Roads and Structures.

B. MATERIALS

1. All pipe used for construction of Landfill Gas Vents shall be either solid (riser pipe) or perforated (collector pipe) 6 inch diameter schedule 80 polyvinyl chloride (PVC) pipe as shown on the Contract Drawings.

2. Backfill for Landfill Gas Vents shall be NCDOT #57 stone.

3. Geotextiles used for Landfill Gas Vents shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

4. Turbines: Turbines shall be galvanized steel with aluminum external bracing. Turbines shall have an oil impregnated top bearing and a thrust-type bottom pivot bearing with hardened steel ball riding in a hardened steel seat. Turbines shall be installed complete with all required fittings for a complete installation. Turbines shall be Empire brand, or equal.

C. SUBMITTALS

The Contractor shall furnish copies of the delivery tickets or other approved receipts to the Engineer as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. All Landfill Gas Vents shall be constructed at the locations and according to the details shown on the Contract Drawings. Care shall be taken to ensure that these locations are not in areas which are prone to pond water.

2. The depth of Landfill Gas Vents shall be adjusted such that the perforated PVC piping and stone backfill lies below the existing intermediate cover and in contact with the underlying waste.

3. The Contractor shall exercise caution as excavations will extend into existing municipal solid waste. The Contractor shall construct Landfill Gas Vents such that Contractor personnel are not required to enter the excavation.

4. All waste materials removed during construction of Landfill Gas Vents shall be disposed of on site in the active lined landfill as directed by the Owner and Engineer.

END OF SECTION

Construction Quality Assurance Manual

Johnston County
C&D Landfill Vertical Expansion

Prepared for:
Johnston County Department of Public Utilities
Smithfield, North Carolina

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G.N. Richardson & Associates, Inc.
Engineering and Geological Services
14 N. Boylan Avenue
Raleigh, North Carolina 27603

JOHNSTON COUNTY
C&D LANDFILL VERTICAL EXPANSION

CONSTRUCTION QUALITY ASSURANCE MANUAL

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APPENDICES

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 geosynthetics components of the final cover system. The final cover system consists of a geosynthetic clay liner or LLDPE geomembrane, overlying granular and geosynthetic drainage material with collection piping, and overlying 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 Geosynthetic Clay Liner CQA
- Section 7.0 Geotextile CQA
- Section 8.0 Geonet Drainage Media 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 Johnston 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 shall also be responsible for proper resolution of all quality issues that arise during construction. The Engineer is G.N. Richardson & Associates, Inc.

1.3.1.3 Contractor

The Contractor is responsible for the construction of the subgrade, earthwork, and for placement of the final cover system. 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 earthworks at the site, and the installation 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. The Geomembrane Installer must be approved by the Geomembrane Manufacturer.

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 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 fills 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.

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. 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 report. 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 shall 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 shall 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 shall 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** shall be included in the Final CQA Report.

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
2.0 Project Description
3.0 CQA Program
    3.1 Scope of Services
    3.2 Personnel
4.0 Earthwork CQA
5.0 Final Cover System CQA
6.0 Geomembrane CQA
7.0 Geonet Drainage Media CQA
8.0 Geotextile CQA
9.0 GCL CQA
10.0 Summary and Conclusions
11.0 Project Certification

Appendices

Appendix A Specification Clarifications/Modifications
Appendix B Photographic Documentation
Appendix C CQA Reporting
    C1 CQA Reports
    C2 CQA Meeting Minutes
Appendix D Earthwork CQA Data
    D1 CQA Test Results
Appendix E Final Cover System CQA Data
    E1 CQA Test Results
Appendix F Geomembrane CQA Data
    F1 Manufacturer's Product Data Submittals and Quality Control Certificates
    F2 Subgrade Acceptance Certificates
    F3 Trial Seam Logs
    F4 CQA Test Results
Appendix G Geonet Drainage Media CQA Data
    G1 Manufacturer's Product Data Submittals and Quality Control Certificates
    G2 CQA Test Results

TABLE 2.1 (CONTINUED):

Appendix H	Geotextile CQA Data	
	H1	Manufacturer's Product Data Submittals and Quality Control Certificates
	H2	CQA Test Results
Appendix I	GCL CQA Data	
	I1	Manufacturer's Product Data Submittals and Quality Control Certificates
	I2	CQA Test Results
Appendix J	Record Drawings	

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 shall 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 shall 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 shall 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 shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall 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 2922[1]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)
Moisture Content	ASTM D 3017[2]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)

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.

SECTION 4.0
FINAL COVER SYSTEM CQA

4.1 INTRODUCTION

This section of the CQA Manual addresses the landfill gas (LFG) system, drainage aggregate and piping, and the vegetative soil layer of the final cover system. By reference to **Sections 5.0, 6.0, 7.0, and 8.0** of this CQA Manual, this section also addresses the geomembrane, geonet drainage media, geotextiles, and geosythetic clay liner 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 High Density Polyethylene (HDPE) Pipe

A. Receipt of Contractor's submittals on HDPE pipe.

B. Review of submittals for HDPE pipe for conformity to the project specifications.

C. Conduit lines external to the collection system are to be pressure tested as required by the project specifications and demonstrated to be leak-free.

4.2.2 Polyvinyl Chloride (PVC) Pipe

A. Receipt of Contractor's submittals on PVC pipe.

B. Review of submittals for PVC pipe for conformity to the project specifications.

4.2.3 Corrugated Polyethylene (CPE) Pipe

A. Receipt of Contractor's submittals on CPE pipe.

B. Review of submittals for CPE pipe for conformity to the project specifications.

4.2.4 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.

4.2.5 Aggregates (Verify for each type of aggregate)

A. Receipt of Contractor's submittals on aggregates.

B. Review of submittals for aggregates for conformity to the project specifications.

C. Verify that aggregates in stockpiles or at borrow sources conform to the project specifications.

D. Conduct material control tests in accordance with **Table 4.1**.

4.2.6 Geomembrane

The CQA program for geotextiles is presented in **Section 5.0** of this CQA Manual.

4.2.7 Geosynthetic Clay Liner (GCL)

The CQA program for GCL is presented in **Section 6.0** of this CQA Manual.

4.2.8 Geotextiles

The CQA program for geotextiles is presented in **Section 7.0** of this CQA Manual.

4.2.9 Geonet Drainage Media

The CQA program for geonet drainage media is presented in **Section 8.0** of this CQA Manual.

4.2.10 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 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 shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

TABLE 4.1: CQA TESTING PROGRAM FOR LCR 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

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 intermediate cover 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. In addition, no panels not specifically shown on the seam layout drawing may be used without the Engineer's prior approval.

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, the Geomembrane Installer shall make trial seams on appropriate sized pieces of identical or equivalent geomembrane material to verify that seaming conditions and procedures are adequate.

B. Trial seams shall be performed for each welder to be used and by each operator of extrusion welders, and by the primary operator of each fusion welder. A passing trial seam shall be made prior to the beginning of each seaming period. Typically, this is at the start of the day and after lunch break.

C. Fusion welded trial seams shall be approximately 72" x 12" with the seam centered lengthwise. For extrusion welding, the trial seams shall be approximately 36" x 12" with the seam centered lengthwise. A minimum of four coupons will 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 shall 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 seam welds 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 shall 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 will obtain 12" x 24" (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 weld. The sample shall be cut into two equal-length pieces, one to be given to the Geomembrane Installer for field destructive seam testing 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. A minimum of five coupons each will be tested in peel and shear (ASTM D 6392) by the Geomembrane Installer using a field tensiometer. Four of five 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 will obtain 12" x 24" (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 coupons each will be tested in peel and shear (ASTM D 6392) by the Geosynthetics CQA Laboratory. Four of five 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 shall 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 weld 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 Installer and the Geosynthetic Manufacturers will retain all ownership and responsibility for the geosynthetics in the landfill unit until acceptance by the Owner.

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 furnishes 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;
- all documentation of the installation is completed including the CQA Engineer's final report; and
- certification by the CQA Engineer, including Record Drawing(s), sealed by a Professional Engineer registered in the state in which the project is located, has been received by the Engineer.

The CQA Engineer will certify that the installation has proceeded in accordance with this CQA Manual and the project specifications for the project except as noted to the Engineer.

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 shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall 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 638 (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

SECTION 6.0
GEOSYNTHETIC CLAY LINER (GCL) CQA

6.1 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.

6.2 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.

6.3 GCL MATERIAL APPROVAL

6.3.1 GCL Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

6.3.2 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.

6.3.3 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.

6.3.4 GCL 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 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.

6.3.4.1 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.

6.4 GCL INSTALLATION

6.4.1 Handling And Placement

The Geosynthetic Installer will handle and place all GCL in such a manner as required by the project specifications.

6.4.2 Seams And Overlaps

All GCL will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

6.4.3 Repairs

Any holes or tears in the GCL will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

6.4.4 Placement Of Overlying Materials

All soil materials located on top of the GCL shall be placed in accordance with the project specifications.

6.5 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 shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

TABLE 6.1: 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]
Grab Tensile Strength	ASTM D 4632	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

SECTION 7.0
GEOTEXTILE CQA

7.1 INTRODUCTION

This section of the CQA Manual addresses geotextiles and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

7.2 GEOTEXTILE MATERIAL APPROVAL

7.2.1 Geotextile Product Data

For each type of geotextile to be used, the CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

7.2.2 Shipment And Storage

During shipment and storage, all geotextiles will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

7.2.3 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.

7.2.4 Geotextile 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 geotextiles. 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 geotextiles. The

CQA Engineer will examine all results from laboratory testing.

7.2.4.1 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 geotextile 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.

7.3 GEOTEXTILE INSTALLATION

7.3.1 Handling And Placement

The Geosynthetic Installer will handle and place all geotextiles in such a manner as required by the project specifications.

7.3.2 Seams And Overlaps

All geotextiles will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

7.3.3 Repairs

Any holes or tears in the geotextile will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

7.3.4 Placement Of Overlying Materials

All soil materials located on top of a geotextile shall be placed in accordance with the project specifications.

7.4 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 shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

TABLE 7.1: CQA TESTING PROGRAM FOR GEOTEXTILE MATERIAL APPROVAL

PROPERTY	TEST METHOD	TEST FREQUENCY
CONTROL TESTS:		
Grab Tensile Strength	ASTM D 4632	100,000 ft^2 or 1 per Lot[1]
Puncture Resistance	ASTM D 4833	100,000 ft^2 or 1 per Lot[1]
Trapezoidal Tear Strength	ASTM D 4533	100,000 ft^2 or 1 per Lot[1]
Apparent Opening Size (AOS) (Type GT-S Geotextile Only)	ASTM D 4751	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.
2. CQA testing is not required for geotextiles placed outside of the containment area.

SECTION 8.0
GEONET DRAINAGE MEDIA CQA

8.1 INTRODUCTION

This section of the CQA Manual addresses geonet drainage media (GDM) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

8.2 GDM MATERIAL APPROVAL

8.2.1 GDM Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

8.2.2 Shipment And Storage

During shipment and storage, all GDM will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

8.2.3 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.

8.2.4 GDM Material Control Tests

Samples for material control tests, as shown on **Table 8.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the GDM. 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 GDM. The CQA

Engineer will examine all results from laboratory testing.

8.2.4.1 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 GDM 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.

8.3 GDM INSTALLATION

8.3.1 Handling And Placement

The Geosynthetic Installer will handle and place all GDM in such a manner as required by the project specifications.

8.3.2 Stacking And Joining

When several layers of GDM are stacked, care should be taken to ensure that stacked GDM are placed in the same direction. Stacked GDM will never be laid in perpendicular directions to the underlying GDM (unless otherwise specified by the Engineer). The CQA Engineer will observe the stacking of GDM.

Adjacent rolls of GDM will be joined according to construction drawings and project specifications.

8.3.3 Repairs

Any holes or tears in the GDM will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

8.3.4 Placement Of Overlying Materials

All soil materials located on top of GDM shall be placed in accordance with the project specifications.

8.4 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 shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

TABLE 8.1: CQA TESTING PROGRAM FOR GDM 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.

Appendix A

Reference List of Test Methods

JOHNSTON COUNTY
C&D LANDFILL VERTICAL EXPANSION

CQA MANUAL
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 638	Standard Test Method for Tensile Properties of Plastics.
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 2922	Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
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.

Geosynthetic Research Institute (GRI):

GRI GC7	Determination of Adhesion and Bond Strength of Geocomposites.

Erosion and Sedimentation Control Plan

Johnston County C&D Landfill Vertical Expansion
Johnston County, North Carolina

Prepared For:

Johnston County Department of Public Utilities
309 East Market Street
Smithfield, North Carolina 27577

Prepared By:

G.N. Richardson & Associates, Inc.
Engineering and Geological Services
14 N. Boylan Avenue
Raleigh, North Carolina 27603

December 2003

JOHNSTON COUNTY
C & D LANDFILL VERTICAL EXPANSION

EROSION AND SEDIMENTATION CONTROL PLAN

TABLE OF CONTENTS

APPENDICES

JOHNSTON COUNTY
C & D LANDFILL VERTICAL EXPANSION

EROSION AND SEDIMENTATION CONTROL PLAN

1.0 NARRATIVE

1.1 Project Description

Johnston County plans to construct an expansion of their existing construction and demolition debris (C&D) landfill at their existing landfill facility near Smithfield. The construction and operation of the C&D landfill will require the disturbance of approximately 18.9 acres (of which 4.2 acres have not been previously permitted) which will create the potential for erosion and the transportation of sediment. This plan discusses the erosion and sedimentation control measures used on this project to counter this threat of erosion.

1.2 Contact Information

1.2.1 Engineer: For questions regarding this erosion and sedimentation control plan, please contact the following:

G.N. Richardson & Associates, Inc.
Attn.: Pieter K. Scheer, P.E.
14 N. Boylan Ave.
Raleigh, NC 27607
(919) 828-0577
FAX: 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:

Johnston County Department of Public Utilities
Attn.: Haywood Phthisic, Director
P.O. Box 2263
309 E. Market Street
Smithfield, NC 27577
(919) 209-8333
FAX: 934-7174.

1.3 Existing Site Conditions

The proposed C & D landfill expansion occupies approximately 18.9 acres on top of the Phase 4 MSW landfill. Note that the first 14.7 acre portion of this area (currently active) received a permit on February 18, 2002. Existing ground surface elevations on the Phase

4 area vary from El. 240 (feet) at the south end of the proposed fill, decreasing to El. 185 at the north end. Currently, undisturbed portions of the area are well vegetated with grass.

1.4 Adjacent Areas

The proposed site borders County landfill property on all sides.

1.5 Site Soils Information

The proposed fill areas overlie former MSW fill areas with 24 plus inches of soil cover. Borrow soils proposed for use as periodic and final cover for the C & D landfill expansion are generally classified as silty sand (SM).

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 North Carolina Erosion and Sediment Control Planning and Design Manual (E&SCP&DM) and "Elements of Urban Stormwater Design" (EOUSD), by H. Rooney Malcom, P.E. Design calculations are provided as an attachment to this plan.

All stormwater flow volumes were calculated using the Rational Method based on the maximum rate of runoff from a 25-year storm event. Runoff coefficients for various ground cover conditions are referenced to Table 8.03a in the E&SCP&DM. Rainfall intensities used in the Rational Method were derived from an analysis of design storms for the site. Times of concentration were calculated with the Kirpich Equation. Drainage areas were determined using a planimeter and/or AutoCAD on topographic sheets of the project area.

3.0 EROSION AND SEDIMENTATION CONTROL MEASURES

The following erosion and sedimentation control measures are to be used in construction 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.

3.1 Sediment Basins

There are four existing permanent sediment basins which will serve the site. Existing Sediment Basins 1 and 2 are located to the west of the project area. Existing Sediment Basin No. 6 is located to the east of the project area. Existing Sediment Basin No. 5A is located on the northwest of the project area. Each of the existing Sediment Basins will receive flow from less disturbed area than originally designed and, thus, were not analyzed in the calculations.

3.2 Drainage Channels

Drainage channel calculations were conducted using a reformulation of Manning's Equation to calculate normal depth of flow, as set forth in EOUSD, for given conditions to establish ditch capacity and velocity of flow. For conservatism, the channel calculations assume peak flow over maximum slope of channel reach in determining velocity. Channels were first checked assuming just constructed, bare earth, conditions. The maximum allowable velocity for bare earth was assumed to be 2.5 feet per second (Table 8.05d E&SCP&DM). If velocity exceeded this value, a temporary liner was chosen if appropriate. Normal depth and velocity was then calculated assuming grass lining as a minimum constructed condition. The allowable velocity for grass lining was assumed to be 4.5 feet per second (Table 8.05a, E&SCP&DM). If velocity exceeded this, a permanent liner was designed. Both temporary and permanent channel linings were designed using the Tractive Force Procedure as outlined in E&SCP&DM.

3.3 Diversion Berms and Down Pipes

Upon reaching final design grades in the landfill, drainage structures including diversion berms and down pipes will be installed. Down pipes were designed as culverts based on an analysis of inlet and outlet control under the influence of the design storm to determine the governing headwater condition. The inlet of down pipes collecting flow from top areas will be protected from excess sedimentation by use of a gravel and rip rap filter berm. Filter berms were designed using criteria and standard cross section from E&SCP&DM. Down pipes will be adequately anchored to the landfill side slopes and each will be outleted to the stabilized perimeter channels or to rip rap aprons. Rip rap aprons were designed based on criteria set forth in E&SCP&DM, Section 6.41.

3.4 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 6.11p of E&SCP&DM which is applicable to this site. Temporary or permanent ground cover adequate to restrain erosion shall be placed on disturbed areas within 15 working days or 30 calendar days (whichever is shorter) following completion of any phase of grading.

4.0 SCHEDULE FOR IMPLEMENTATION

All new erosion control measures described herein are planned to be placed as part of final cover construction. All areas reaching final elevations will be vegetated.

5.0 MAINTENANCE AND SEDIMENT DISPOSAL

All erosion and sedimentation control devices will be inspected at regular intervals and immediately following any significant rainfall event. Repairs will then 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.

Appendix A

Erosion & Sedimentation Control Calculations

JOHNSTON COUNTY
C&D LANDFILL VERTICAL EXPANSION

EROSION AND SEDIMENTATION CONTROL PLAN
APPENDIX A: EROSION AND SEDIMENTATION CONTROL CALCULATIONS

TABLE OF CONTENTS

PROJECT Johnston County - CDLF Expansion

SUBJECT Erosion & Sedimentation Control

SHEET 1 OF 2
JOB NO. JOHNSTON-21
DATE 12/8/03
COMPUTED BY PKS
CHECKED BY

Objective

To design erosion and sedimentation control structures to remove and contain storm water flow from the design storm at the proposed facility.

Calculations will be based on:

- Rational Method
- Rainfall Frequencies for the Site

Analysis

The main design criteria will be to ensure that all storm water conveyance and retention structures will be able to accommodate the peak rate of run off from the design storm without erosion.

The erosion control measures will be designed to control sedimentation from time of construction until the site is stabilized.

References

North Carolina Erosion & Sediment Control Planning & Design Manual, North Carolina Division of Land Resources, 1988.

Malcom, H. Rooney, Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC, 1989.

Calculations

- Rational Method (Flow Rate, Q):

$Q = CIA$ (cfs) (Malcom Eq. I -1)

where: C = Rational Runoff Coefficient
I = Applicable Rainfall Intensity (in/hr) of storm event (Based on Time of Concentration)
A = Drainage Area (Acres)

E&SC.WPD

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

- Time of Concentration (t_c) (Kirpich Equation):

$$t_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128} \quad \text{(minutes)} \qquad \text{(Malcom Eq. I-2)}$$

where: L = Hydraulic Length of Watershed to Point of Interest (ft)

H = Fall Along L (ft)

Note: I is found by calculating t_c and using a rainfall intensity - duration - frequency graph or table suitable to the site. t_c (minimum) = 5 minutes.

PROJECT Johnston County - CDLF Expansion

SUBJECT Analysis of Design Storms

SHEET 1 OF 2
JOB NO. JOHNSTON-21
DATE 12/8/03
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, "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, 1977.

U.S. Weather Bureau, "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, 1961.

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

G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

Johnston County Landfill
Analysis of Design Storms

SHEET: 2/2
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

INPUT DATA:
LOCATION: Smithfield, NC

DURATION	2-YR P (in)	100-YR P (in)	SOURCE
5 min	0.48	0.81	NOAA HYDRO-35
15 min	1.03	1.81	NOAA HYDRO-35
60 min	1.80	3.75	NOAA HYDRO-35
2 hr to 24 hr Rainfall Events	**USER INPUT**		USWB TP-40

DEPTH-DURATION-FREQUENCY TABLE
LOCATION: Smithfield, NC

	RETURN PERIOD						
DURATION	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	1.03	1.17	1.29	1.40	
15 min	1.03	1.20	1.32	1.51	1.66	1.81	
30 min	1.41	1.72	1.94	2.26	2.51	2.76	
60 min	1.80	2.26	2.58	3.04	3.39	3.75	
2 hr	2.20	2.80	3.25	3.70	4.20	4.60	**USER INPUT**
3 hr	2.40	3.10	3.60	4.10	4.55	5.10	**USER INPUT**
6 hr	2.85	3.60	4.20	4.90	5.50	6.10	**USER INPUT**
12 hr	3.35	4.20	5.00	5.80	6.40	7.20	**USER INPUT**
24 hr	3.70	4.85	5.80	6.60	7.40	8.20	**USER INPUT**

INTENSITY-DURATION-FREQUENCY TABLE
LOCATION: Smithfield, NC

	RETURN PERIOD					
DURATION	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	4.83	5.59	6.17	7.03	7.72	8.40
15 min	4.12	4.79	5.29	6.05	6.65	7.24
30 min	2.81	3.43	3.88	4.52	5.02	5.52
60 min	1.80	2.26	2.58	3.04	3.39	3.75
2 hr	1.10	1.40	1.63	1.85	2.10	2.30
3 hr	0.80	1.03	1.20	1.37	1.52	1.70
6 hr	0.48	0.60	0.70	0.82	0.92	1.02
12 hr	0.28	0.35	0.42	0.48	0.53	0.60
24 hr	0.15	0.20	0.24	0.28	0.31	0.34

PROJECT Johnston County - CDLF Expansion

SUBJECT Drainage Areas

SHEET 1 OF 2
JOB NO. JOHNSTON-21
DATE 12/8/03
COMPUTED BY PKS
CHECKED BY

Objective

To breakout drainage areas for use in determining worst case design conditions for each erosion control measure. Drainage areas for the are labeled as "1, 2, 3, etc." Areas were measured by planimeter or AutoCAD on the attached plan drawings. Below is a summary of drainage areas used in erosion control calculations. Plan sheets with delineations of drainage areas are attached.

Analysis

- Drainage Areas:

Area	Area (Acres)
1	1.2
2	1.4
3	0.8
4	2.4
5	2.3
6	1.6
7	0.6
8	1.8
9	6.8

DRAINAGE AREAS.WPD

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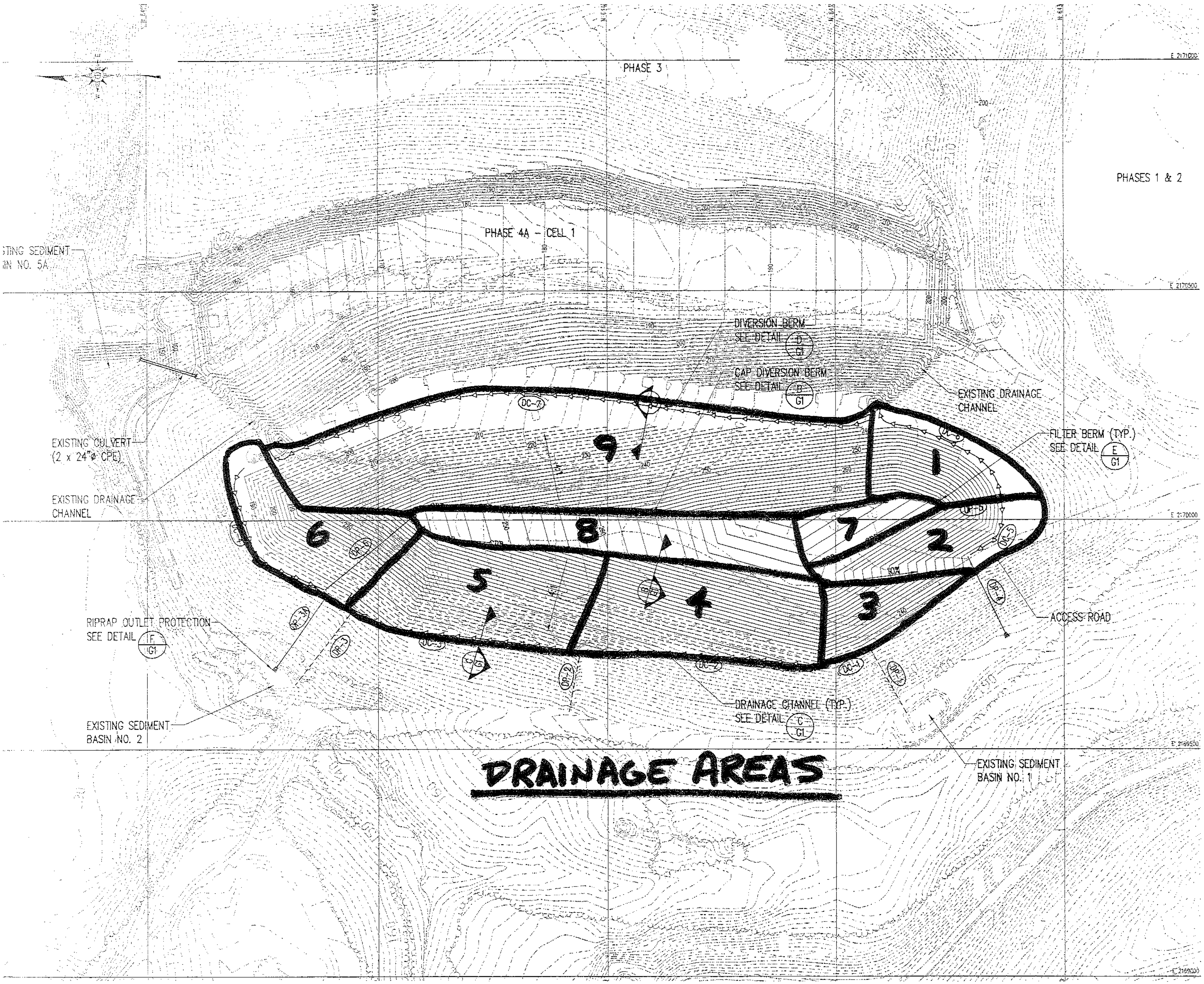
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577



DOWN PIPE SCHEDULE				
DOWN PIPE NO.	SIZE/TYPE	LENGTH	INV. IN	INV. OUT
DP-1 (EXISTING)	18"φ CPE (TYPE C)	160'	232.0	194.0
DP-2 (EXISTING)	18"φ CPE (TYPE C)	150'	208.0	178.0
DP-3 (EXISTING)	18"φ CPE (TYPE C)	210'	185.0	142.0
DP-3A	24"φ CPE (TYPE C)	200'	185.0	142.0
DP-4	18"φ CPE (TYPE C)	190'	240.0	200.0
DP-5	18"φ CPE (TYPE C)	130'	271.0	241.0
DP-6	18"φ CPE (TYPE C)	240'	241.0	186.0

LEGEND

- EXISTING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- 270 PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR
- DC-1 CHANNEL
- DB DIVERSION BERM
- CDB CAP DIVERSION BERM
- DP-3A DOWN PIPE
- DP-1 EXISTING DOWN PIPE

NOTES

1. CAP CONTOURS SHOWN REPRESENT TOP OF FINAL COVER.

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORPORATION, ZEBULON, NC, BASED ON MARCH 8, 2001 AERIAL PHOTOGRAPHY.
2. TOPOGRAPHY IN PHASE 5 AREA PROVIDED BY SOUTHWIND SURVEYING AND ENGINEERING, GARNER, NC, DATED JUNE 16, 2003.

G.N. RICHARDSON & ASSOCIATES, IN
Engineering and Geological Service
14 N. BOYLAN AVENUE RALEIGH, N.C. 2760
PHONE-919-828-0577 FAX-919-828-3899 WWW.GNRA.C

JOHNSTON COUNTY
C & D LANDFILL
VERTICAL EXPANSION
PERMIT MODIFICATION

EROSION AND SEDIMENT CONTROL PLAN

SCALE: AS SHOWN

2/2

PROJECT Johnston County - CDLF Expansion

SUBJECT Normal Depth Analysis

SHEET 1 OF 10
JOB NO. JOHNSTON-21
DATE 12/8/03
COMPUTED BY PKS
CHECKED BY

Objective To design ditches and channels to remove storm water flow from the design storm at the proposed facility.

Analysis The main design criteria will be to ensure that all ditches and channels will be able to accommodate the peak rate of run off from the design storm without erosion.

References North Carolina Erosion & Sediment Control Planning & Design Manual, North Carolina Division of Land Resources, 1988.

Malcom, H. Rooney, Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC, 1989.

Calculations

- Determine Peak Flow Rate to Ditch/Channel:

  Use Rational Method ($Q_P = CIA$)

- Manning's Equation:

$$Q = \frac{1.49 A R^{2/3} S^{1/2}}{n} = AV$$ (Malcom Eq. I-8)

where:
- Q = Discharge/Flow Rate (cfs)
- n = Manning's Roughness Coefficient
- A = Cross Sectional Area of Flow (ft^2)
- R = Hydraulic Radius (ft) = A/Wetted Perimeter
- S = Slope of Channel (ft/ft)
- V = Average Channel Velocity (ft/sec)

NDEPTH.WPD

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- Tractive Force Procedure:

T = yds

where:

T	=	Shear Stress on Channel Lining (lb/ft^2)
y	=	Unit Weight of Water (62.4 lb/ft^3)
d	=	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)

If Fr is greater than 1.0, flow is supercritical; if it is under 1.0, flow is subcritical. Fr is 1.0 for critical flow conditions.

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ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 3/10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Channel #1

Peak Flow Rate:

Drainage Area (Ac.) =	0.8	(User Input)	(Area 3)
Hydraulic Length (ft) =	200	(User Input)	(Head of Area 3 to DP-1 Inlet)
Fall Along Length (ft) =	24	(User Input)	(EL. 256 - EL. 232)
Time of Conc. (min.) =	1.0		
Intensity (in/hr) =	8.19	(User Input)	(25 Year Storm)
Runoff Coefficient =	0.35	(User Input)	(EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)
Q (cfs) =	2.3		

Ditch/Channel Parameters: (User Input)

Lining:	6" Rip Rap	
Maximum Slope (ft/ft) =	0.04	
Minimum Slope (ft/ft) =	0.02	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	2	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.23085906	
y (ft) =	0.55	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.23750548	
Normal Depth (ft) =	0.55	

Velocity:

V (ft/s) = 3.90

Liner Shear Stress:

T (lb/ft^2) = 1.37

Froude Number:

Fr = 1.31

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.32648401	
y (ft) =	0.62	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.32690205	
Normal Depth (ft) =	0.62	

Velocity:

V (ft/s) = 2.99

Liner Shear Stress:

T (lb/ft^2) = 0.77

Froude Number:

Fr = 0.95

G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 4 / 10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Channel #2

Peak Flow Rate:

Drainage Area (Ac.) =	2.4 (User Input)	(Area 4)
Hydraulic Length (ft) =	725 (User Input)	(Head of Area 4 to DP-2 Inlet)
Fall Along Length (ft) =	64 (User Input)	(EL. 272 - EL. 208)
Time of Conc. (min.) =	3.2	
Intensity (in/hr) =	8.19 (User Input)	(25 Year Storm)
Runoff Coefficient =	0.35 (User Input)	(EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)
Q (cfs) =	6.9	

Ditch/Channel Parameters: (User Input)

Lining:	6" Rip Rap	
Maximum Slope (ft/ft) =	0.08	
Minimum Slope (ft/ft) =	0.02	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	2	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.48972602	
y (ft) =	0.73	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.50532113	
Normal Depth (ft) =	0.73	

Velocity:

V (ft/s) = 6.66

Liner Shear Stress:

T (lb/ft^2) = 3.64

Froude Number:

Fr = 1.94

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.97945204	
y (ft) =	0.94	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.99170114	
Normal Depth (ft) =	0.94	

Velocity:

V (ft/s) = 3.94

Liner Shear Stress:

T (lb/ft^2) = 1.17

Froude Number:

Fr = 1.01

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ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 5 / 10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Channel #3

Peak Flow Rate:

Drainage Area (Ac.) =	2.3	(User Input)	(Area 5)
Hydraulic Length (ft) =	675	(User Input)	(Head of Area 5 to DP-3 Inlet)
Fall Along Length (ft) =	74	(User Input)	(EL. 259 - EL. 185)
Time of Conc. (min.) =	2.8		
Intensity (in/hr) =	8.19	(User Input)	(25 Year Storm)
Runoff Coefficient =	0.35	(User Input)	(EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)
Q (cfs) =	6.6		

Ditch/Channel Parameters: (User Input)

Lining:	6" Rip Rap	
Maximum Slope (ft/ft) =	0.08	
Minimum Slope (ft/ft) =	0.02	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	2	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.46932077	
y (ft) =	0.72	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.48707199	
Normal Depth (ft) =	0.72	

Velocity:

V (ft/s) = 6.60

Liner Shear Stress:

T (lb/ft^2) = 3.59

Froude Number:

Fr = 1.94

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.93864154	
y (ft) =	0.93	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.96381659	
Normal Depth (ft) =	0.93	

Velocity:

V (ft/s) = 3.91

Liner Shear Stress:

T (lb/ft^2) = 1.16

Froude Number:

Fr = 1.01

G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 6 / 10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Channel #4

Peak Flow Rate:

Drainage Area (Ac.) =	3.4	(User Input)	(Areas 6 & 8) A
Hydraulic Length (ft) =	1200	(User Input)	(Head of Area 8 to DP-3 Inlet)
Fall Along Length (ft) =	95	(User Input)	(EL. 280 - EL. 185)
Time of Conc. (min.) =	4.9		
Intensity (in/hr) =	8.19	(User Input)	(25 Year Storm)
Runoff Coefficient =	0.35	(User Input)	(EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)
Q (cfs) =	9.7		

Ditch/Channel Parameters: (User Input)

Lining:	6" Rip Rap	
Maximum Slope (ft/ft) =	0.03	
Minimum Slope (ft/ft) =	0.015	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	2	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	1.1329356	
y (ft) =	1	(Iterate)
accuracy =	0.1	
f(M,y,B) =	1.16960678	
Normal Depth (ft) =	1	

Velocity:
V (ft/s) = 5.03

Liner Shear Stress:
T (lb/ft^2) = 1.87

Froude Number:
Fr = 1.25

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	1.60221288	
y (ft) =	1.13	(Iterate)
accuracy =	0.1	
f(M,y,B) =	1.62025142	
Normal Depth (ft) =	1.13	

Velocity:
V (ft/s) = 3.86

Liner Shear Stress:
T (lb/ft^2) = 1.06

Froude Number:
Fr = 0.90

NDEPTH.WB3(4)

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SHEET: 7/10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Channel #5

Peak Flow Rate:

Drainage Area (Ac.) =	1.4	(User Input)	(Area 2)
Hydraulic Length (ft) =	350	(User Input)	(Head of Area 2 to DP-4 Inlet)
Fall Along Length (ft) =	32	(User Input)	(EL. 272 - EL. 240)
Time of Conc. (min.) =	1.8		
Intensity (in/hr) =	8.19	(User Input)	(25 Year Storm)
Runoff Coefficient =	0.35	(User Input)	(EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)
Q (cfs) =	4.0		

Ditch/Channel Parameters: (User Input)

Lining:	6" Rip Rap	
Maximum Slope (ft/ft) =	0.04	
Minimum Slope (ft/ft) =	0.015	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	2	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.40400336	
y (ft) =	0.68	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.41821242	
Normal Depth (ft) =	0.68	

Velocity:

V (ft/s) = 4.49

Liner Shear Stress:

T (lb/ft^2) = 1.70

Froude Number:

Fr = 1.36

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.65973472	
y (ft) =	0.81	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.66680661	
Normal Depth (ft) =	0.81	

Velocity:

V (ft/s) = 3.09

Liner Shear Stress:

T (lb/ft^2) = 0.76

Froude Number:

Fr = 0.86

NDEPTH.WB3(5)

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SHEET: 8 / 10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Channel #6

Peak Flow Rate:

Drainage Area (Ac.) =	1.8	(User Input)	(Areas 1 &7)
Hydraulic Length (ft) =	850	(User Input)	(Head of Area 7 to End of Channel #6)
Fall Along Length (ft) =	42	(User Input)	(EL. 280 - EL. 238)
Time of Conc. (min.) =	4.5		
Intensity (in/hr) =	8.19	(User Input)	(25 Year Storm)
Runoff Coefficient =	0.35	(User Input)	(EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)
Q (cfs) =	5.2		

Ditch/Channel Parameters: (User Input)

Lining:	6" Rip Rap	
Maximum Slope (ft/ft) =	0.04	
Minimum Slope (ft/ft) =	0.015	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	2	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.51943289	
y (ft) =	0.74	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.52399171	
Normal Depth (ft) =	0.74	

Velocity:

V (ft/s) = 4.75

Liner Shear Stress:

T (lb/ft^2) = 1.85

Froude Number:

Fr = 1.38

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.84823035	
y (ft) =	0.89	(Iterate)
accuracy =	0.1	
f(M,y,B) =	0.85719549	
Normal Depth (ft) =	0.89	

Velocity:

V (ft/s) = 3.29

Liner Shear Stress:

T (lb/ft^2) = 0.83

Froude Number:

Fr = 0.87

NDEPTH.WB3(6)

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SHEET: 9 / 10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Channel #7

Peak Flow Rate:

Drainage Area (Ac.) =	6.8 (User Input)	(Area 9)
Hydraulic Length (ft) =	1500 (User Input)	(Head of Area 9 to End of Channel #7)
Fall Along Length (ft) =	87 (User Input)	(EL. 277 - EL. 190)
Time of Conc. (min.) =	6.5	
Intensity (in/hr) =	7.84 (User Input)	(25 Year Storm)
Runoff Coefficient =	0.35 (User Input)	(EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)
Q (cfs) =	18.7	

Ditch/Channel Parameters: (User Input)

Lining:	TRM	
Maximum Slope (ft/ft) =	0.06	
Minimum Slope (ft/ft) =	0.02	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	11	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	1.53374225
y (ft) =	0.57 (Iterate)
accuracy =	0.1
f(M,y,B) =	1.54352606
Normal Depth (ft) =	0.57

Velocity:

V (ft/s) = 5.25

Liner Shear Stress:

T (lb/ft^2) = 2.13

Froude Number:

Fr = 1.73

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	2.6565195
y (ft) =	0.7 (Iterate)
accuracy =	0.1
f(M,y,B) =	2.66957723
Normal Depth (ft) =	0.7

Velocity:

V (ft/s) = 3.48

Liner Shear Stress:

T (lb/ft^2) = 0.87

Froude Number:

Fr = 1.04

NDEPTH.WB3(7)

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SHEET: 10/10
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Normal Depth Analysis - Cap Diversion Berm

Peak Flow Rate:

Drainage Area (Ac.) =	1.8	(User Input)	Area 8 (Worst Case)
Hydraulic Length (ft) =	950	(User Input)	Head of Area 8 to DP-6
Fall Along Length (ft) =	40	(User Input)	EL. 280 - EL. 240
Time of Conc. (min.) =	5.2		
Intensity (in/hr) =	8.14	(User Input) (25 Year Storm)	
Runoff Coefficient =	0.35	(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)	
Q (cfs) =	5.1		

Ditch/Channel Parameters: (User Input)

Lining:	ECB	
Maximum Slope (ft/ft) =	0.05	
Minimum Slope (ft/ft) =	0.02	
n =	0.03	(EOUSD - Exhibit 8)
B (ft) =	0	
M =	11	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) = 0.46175854
y (ft) = 0.37 (Iterate)
accuracy = 0.1
f(M,y,B) = 0.48758712
Normal Depth (ft) = 0.37

Velocity:

V (ft/s) = 3.60

Liner Shear Stress:

T (lb/ft^2) = 1.15

Froude Number:

Fr = 1.47

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) = 0.73010436
y (ft) = 0.44 (Iterate)
accuracy = 0.1
f(M,y,B) = 0.77396523
Normal Depth (ft) = 0.44

Velocity:

V (ft/s) = 2.55

Liner Shear Stress:

T (lb/ft^2) = 0.55

Froude Number:

Fr = 0.96

NDEPTH.WB3(8)

PROJECT Johnston County CDLF Expansion

SUBJECT Culvert Analysis

SHEET 1 OF 13
JOB NO. JOHNSTON-21
DATE 12/8/03
COMPUTED BY PKS
CHECKED BY

Objective To analyze culverts for inlet and outlet control. Verify that the allowable headwater depth is not exceeded.

Reference Debo, T.N., and Reese, A.J., Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL, 1995, pp.438-442.

Analysis

- Determine Peak Flow Rate to Culvert:

  Use Rational Method ($Q_P = CIA$)

- Determine Input Parameters:

  - HW_{ALLOW} = Allowable Headwater Depth (ft)
  - N = Number of Pipes Used
  - $Q_{PIPE} = Q_P / N$ (cfs)
  - D = Culvert Diameter (in)
  - Type of Culvert (i.e., Concrete, CMP, etc.)
  - L = Culvert Length (ft)
  - s = Culvert Slope (ft/ft)
  - n = Manning's Number
  - k_e = Entrance Loss Coefficient
  - d_c = Critical Depth (Use Critical Depth Figures) (ft)

- Find actual HW for the culvert for both inlet & outlet control: (The condition with the greatest HW governs.)

  - For Inlet Control:

    - Enter Inlet Control Nomograph with D & Q_{PIPE} and find HW/D for the proper entrance type.
    - Compute HW. If HW exceeds HW_{ALLOW}, try larger culvert.

CULVERT.WPD

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

- For Outlet Control:

- Enter Outlet Control Nomograph with L, K_e, & D.

- To compute HW, connect the length scale for the type of entrance condition and culvert diameter scale with a straight line, pivot on the turning line, and draw a straight line from the design discharge through the turning point to the head loss scale H. Compute HW from the following equation:

$$HW = H + h_o - LS$$

where: $h_o = \left(\frac{d_c + D}{2} \right)$ or tailwater depth, whichever is greater.

- If HW exceeds HW_{ALLOW}, try larger culvert.

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ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 3 / 13
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Culvert Analysis - Down Pipe No. 1 (Existing)

Peak Flow Rate:

Drainage Area (Ac.) =	0.8	(User Input)	Area 3
Hydraulic Length (ft) =	200	(User Input)	Head of Area 3 to Down Pipe No. 1
Fall Along Length (ft) =	24	(User Input)	EL. 256 - EL. 232
Time of Conc. (min.) =	1.0		
Intensity (in/hr) =	8.19	(User Input) (25 Year Storm)	
Runoff Coefficient =	0.35	(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)	
Q (cfs) =	2.3		

Culvert Parameters: (User Input)

Allowable HW Depth (ft) =	2		
Number of Pipes, N =	1	Qpipe (cfs) =	2.3
Culvert Diameter, D (in) =	18		
Type of Culvert =	CPE-C		
Culvert Length, L (ft) =	160		
Culvert Slope, S (ft/ft) =	0.24		
Manning's Number, n =	0.024		
Entrance Loss Coef., ke =	0.5		
Critical Depth (ft) =	0.6		

Case 1: Inlet Control

HW/D = 0.56 (User Input - From Inlet Control Nomograph)
HW (ft) = 0.8

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.1
H (ft) = 0.4 (User Input - From Outlet Control Nomograph)
HW (ft) = -37.0

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SHEET: 4 / 13
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Culvert Analysis - Down Pipe No. 2 (Existing)

Peak Flow Rate:

Drainage Area (Ac.) =	2.4	(User Input)	Area 4
Hydraulic Length (ft) =	725	(User Input)	Head of Area 4 to Down Pipe No. 2
Fall Along Length (ft) =	64	(User Input)	EL. 272 - EL. 208
Time of Conc. (min.) =	3.2		
Intensity (in/hr) =	8.19	(User Input) (25 Year Storm)	
Runoff Coefficient =	0.35	(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)	
Q (cfs) =	6.9		

Culvert Parameters: (User Input)

Allowable HW Depth (ft) =	2		
Number of Pipes, N =	1	Qpipe (cfs) =	6.9
Culvert Diameter, D (in) =	18		
Type of Culvert =	CPE-C		
Culvert Length, L (ft) =	150		
Culvert Slope, S (ft/ft) =	0.2		
Manning's Number, n =	0.024		
Entrance Loss Coef., ke =	0.5		
Critical Depth (ft) =	1.0		

Case 1: Inlet Control

HW/D = 1.2 (User Input - From Inlet Control Nomograph)
HW (ft) = 2

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.3
H (ft) = 2.8 (User Input - From Outlet Control Nomograph)
HW (ft) = -26.0

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SHEET: 5 / 13
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Culvert Analysis - Down Pipe No. 3 (Existing)

Peak Flow Rate:

Drainage Area (Ac.) =	2.3	(User Input)	Area 5
Hydraulic Length (ft) =	675	(User Input)	Head of Area 5 to Down Pipe No. 3
Fall Along Length (ft) =	74	(User Input)	EL. 259 - EL. 185
Time of Conc. (min.) =	2.8		
Intensity (in/hr) =	8.19	(User Input) (25 Year Storm)	
Runoff Coefficient =	0.35	(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)	
Q (cfs) =	6.6		

Culvert Parameters: (User Input)

Allowable HW Depth (ft) =	2		
Number of Pipes, N =	1	Qpipe (cfs) =	6.6
Culvert Diameter, D (in) =	18		
Type of Culvert =	CPE-C		
Culvert Length, L (ft) =	210		
Culvert Slope, S (ft/ft) =	0.2		
Manning's Number, n =	0.024		
Entrance Loss Coef., ke =	0.5		
Critical Depth (ft) =	1.0		

Case 1: Inlet Control

HW/D = 1.1 (User Input - From Inlet Control Nomograph)
HW (ft) = 1.7

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.3
H (ft) = 3.1 (User Input - From Outlet Control Nomograph)
HW (ft) = -37.7

CULVERT.WB3(3)

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SHEET: 6 /13
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Culvert Analysis - Down Pipe No. 3A

Peak Flow Rate:

Drainage Area (Ac.) =	3.4	(User Input)	Areas 6 & 8
Hydraulic Length (ft) =	1200	(User Input)	Head of Area 8 to Down Pipe No. 3A
Fall Along Length (ft) =	95	(User Input)	EL. 280 - EL. 185
Time of Conc. (min.) =	4.9		
Intensity (in/hr) =	8.19	(User Input) (25 Year Storm)	
Runoff Coefficient =	0.35	(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)	
Q (cfs) =	9.7		

Culvert Parameters: (User Input)

Allowable HW Depth (ft) =	2		
Number of Pipes, N =	1	Qpipe (cfs) =	9.7
Culvert Diameter, D (in) =	24		
Type of Culvert =	CPE-C		
Culvert Length, L (ft) =	210		
Culvert Slope, S (ft/ft) =	0.22		
Manning's Number, n =	0.024		
Entrance Loss Coef., ke =	0.5		
Critical Depth (ft) =	1.1		

Case 1: Inlet Control

HW/D = 0.88 (User Input - From Inlet Control Nomograph)
HW (ft) = 1.8

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.6
H (ft) = 1.6 (User Input - From Outlet Control Nomograph)
HW (ft) = -43.1

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SHEET: 7 / 13
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Culvert Analysis - Down Pipe No. 4

Peak Flow Rate:

Drainage Area (Ac.) =	1.4	(User Input)	Area 2
Hydraulic Length (ft) =	350	(User Input)	Head of Area 2 to Down Pipe No. 4
Fall Along Length (ft) =	32	(User Input)	EL. 272 - EL. 240
Time of Conc. (min.) =	1.8		
Intensity (in/hr) =	8.19	(User Input) (25 Year Storm)	
Runoff Coefficient =	0.35	(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)	
Q (cfs) =	4.0		

Culvert Parameters: (User Input)

Allowable HW Depth (ft) =	2		
Number of Pipes, N =	1	Qpipe (cfs) =	4.0
Culvert Diameter, D (in) =	18		
Type of Culvert =	CPE-C		
Culvert Length, L (ft) =	190		
Culvert Slope, S (ft/ft) =	0.21		
Manning's Number, n =	0.024		
Entrance Loss Coef., ke =	0.5		
Critical Depth (ft) =	0.7		

Case 1: Inlet Control

HW/D = 0.79 (User Input - From Inlet Control Nomograph)
HW (ft) = 1.2

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.1
H (ft) = 1.1 (User Input - From Outlet Control Nomograph)
HW (ft) = -37.7

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ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 8 /13
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Culvert Analysis - Down Pipe No. 5

Peak Flow Rate:

Drainage Area (Ac.) =	0.6	(User Input)	Area 7
Hydraulic Length (ft) =	380	(User Input)	Head of Area 7 to Down Pipe No. 5
Fall Along Length (ft) =	10	(User Input)	EL. 280 - EL. 270
Time of Conc. (min.) =	3.1		
Intensity (in/hr) =	8.19	(User Input) (25 Year Storm)	
Runoff Coefficient =	0.35	(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)	
Q (cfs) =	1.7		

Culvert Parameters: (User Input)

Allowable HW Depth (ft) =	2		
Number of Pipes, N =	1	Qpipe (cfs) =	1.7
Culvert Diameter, D (in) =	18		
Type of Culvert =	CPE-C		
Culvert Length, L (ft) =	130		
Culvert Slope, S (ft/ft) =	0.23		
Manning's Number, n =	0.024		
Entrance Loss Coef., ke =	0.5		
Critical Depth (ft) =	0.4		

Case 1: Inlet Control

HW/D = 0.5 (User Input - From Inlet Control Nomograph)
HW (ft) = 0.8

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.0
H (ft) = 0.4 (User Input - From Outlet Control Nomograph)
HW (ft) = -28.6

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ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 9/13
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

Johnston County Landfill - CDLF Expansion
Culvert Analysis - Down Pipe No. 6

Peak Flow Rate:

Drainage Area (Ac.) =	1.8	**(User Input)**	Area 8
Hydraulic Length (ft) =	950	**(User Input)**	Head of Area 8 to Down Pipe No. 6
Fall Along Length (ft) =	40	**(User Input)**	EL. 280 - EL. 240
Time of Conc. (min.) =	5.2		
Intensity (in/hr) =	8.14	**(User Input) (25 Year Storm)**	
Runoff Coefficient =	0.35	**(User Input) (EOUSD - Exhibit 1 - Unimproved, Cleared Conditions)**	
Q (cfs) =	5.1		

Culvert Parameters: (User Input)

Allowable HW Depth (ft) =	2		
Number of Pipes, N =	1	Qpipe (cfs) =	5.1
Culvert Diameter, D (in) =	18		
Type of Culvert =	CPE-C		
Culvert Length, L (ft) =	240		
Culvert Slope, S (ft/ft) =	0.23		
Manning's Number, n =	0.024		
Entrance Loss Coef., ke =	0.5		
Critical Depth (ft) =	0.9		

Case 1: Inlet Control

HW/D = 0.92 **(User Input - From Inlet Control Nomograph)**
HW (ft) = 1.4

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.2
H (ft) = 2.1 **(User Input - From Outlet Control Nomograph)**
HW (ft) = -51.9

CULVERT.WB3(7)

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Table 3-6.1L

ENTRANCE LOSS COEFFICIENTS

Outlet Control, Full or Partly Full Entrance Loss

$$H_e = k_e \frac{V^2}{2g}$$

Type of Structure and Design of Entrance	Coefficient k_e	Standard Plan
Pipe, Concrete		
Projecting from fill (no headwalls)		
Socket end (groove end)	0.2	
Square cut end	0.5	
Beveled end section (mitered to conform to fill slope)	0.7	B-7a
Mitered concrete headwall to conform to fill slope	0.7	B-9
Flared metal end sections (or concrete)	0.5	B-7 Design B
Vertical headwall with wingwalls		B-6 Series
Rounded edge or socket end	0.2	(Modified for
Square edge	0.5	Round Pipe)
Rounded (radius = 1/12 D)	0.2*	
Pipe or Pipe Arch, Corrugated Metal		
Projecting from fill (no headwalls)	0.9	
Beveled end section (mitered to conform to fill slope, no headwall)	0.7	B-7a
Mitered concrete headwall to conform to fill slope	0.7	B-9
Flared metal end sections	0.5	B-7 Design A
Vertical headwall with wingwalls	0.5	B-6 Series
		(Modified for
		Round Pipe)
Box, Reinforced Concrete		
Mitered concrete headwall to conform to fill slope		
Square-edged on 3 edges	0.5	
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2*	
Wingwalls at 30 degrees to 75 degrees to barrel		
Square-edged at crown	0.4	
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2*	
Wingwall at 10 degrees to 25 degrees to barrel		
Square-edged at crown	0.5	B-6 Series
Wingwalls parallel (extension of sides)		
Square-edged at crown	0.7	
Side- or slope-tapered inlet	0.2*	

* Note: Reference Section 3-7.6 for the design of special improved inlets with very low entrance coefficients.

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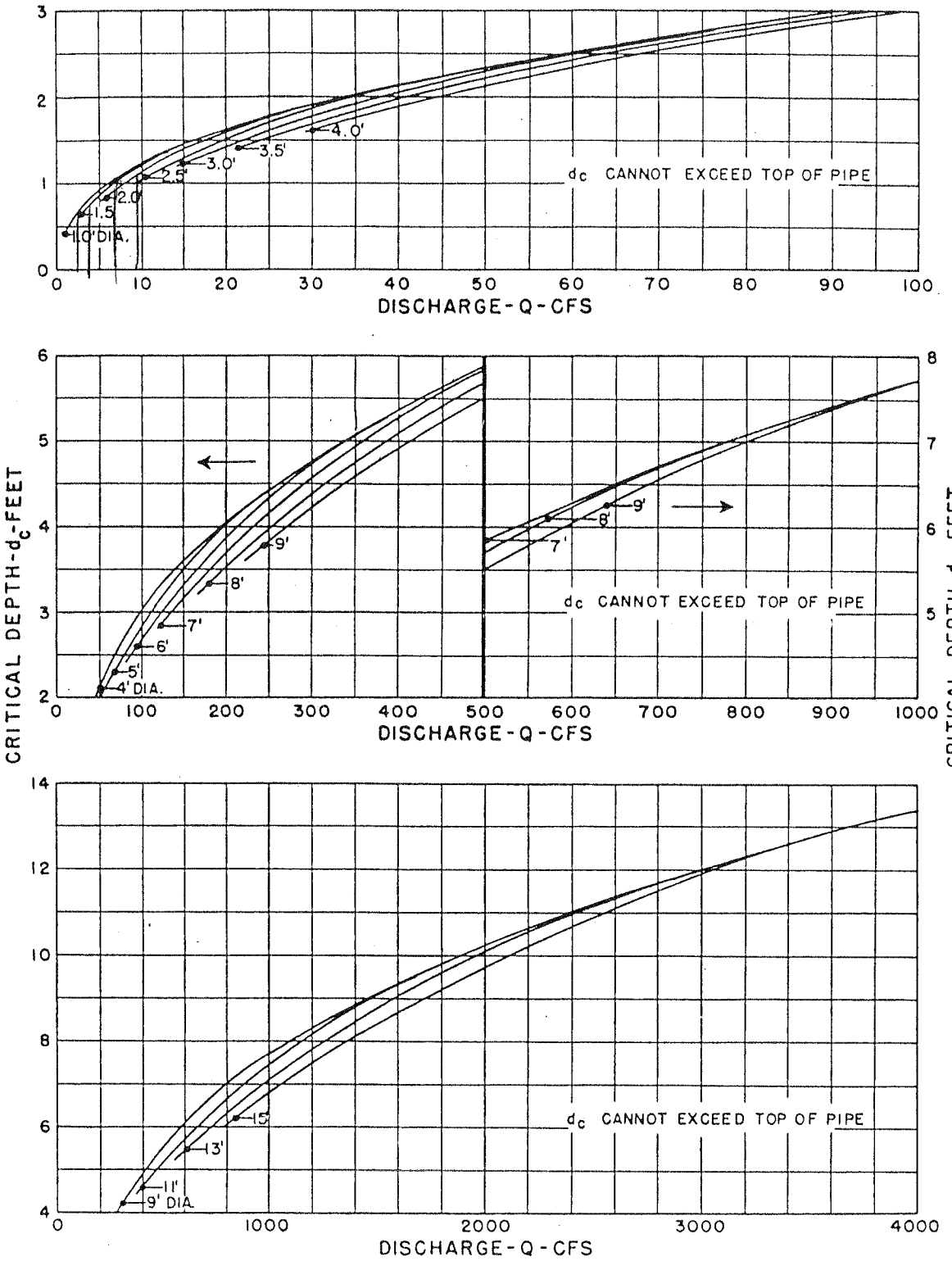

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JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

FIGURE 3-6.1M(1)

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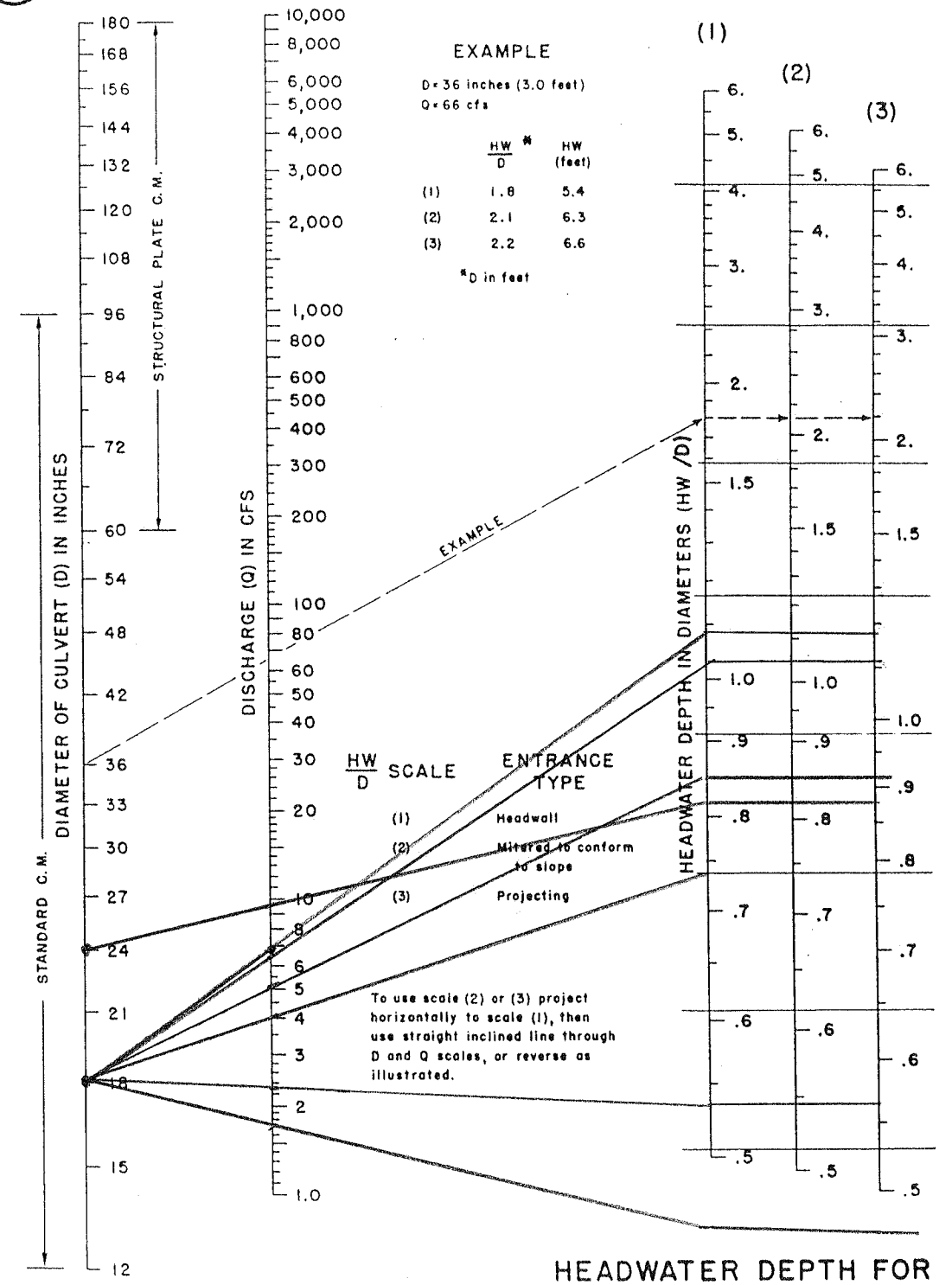

HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

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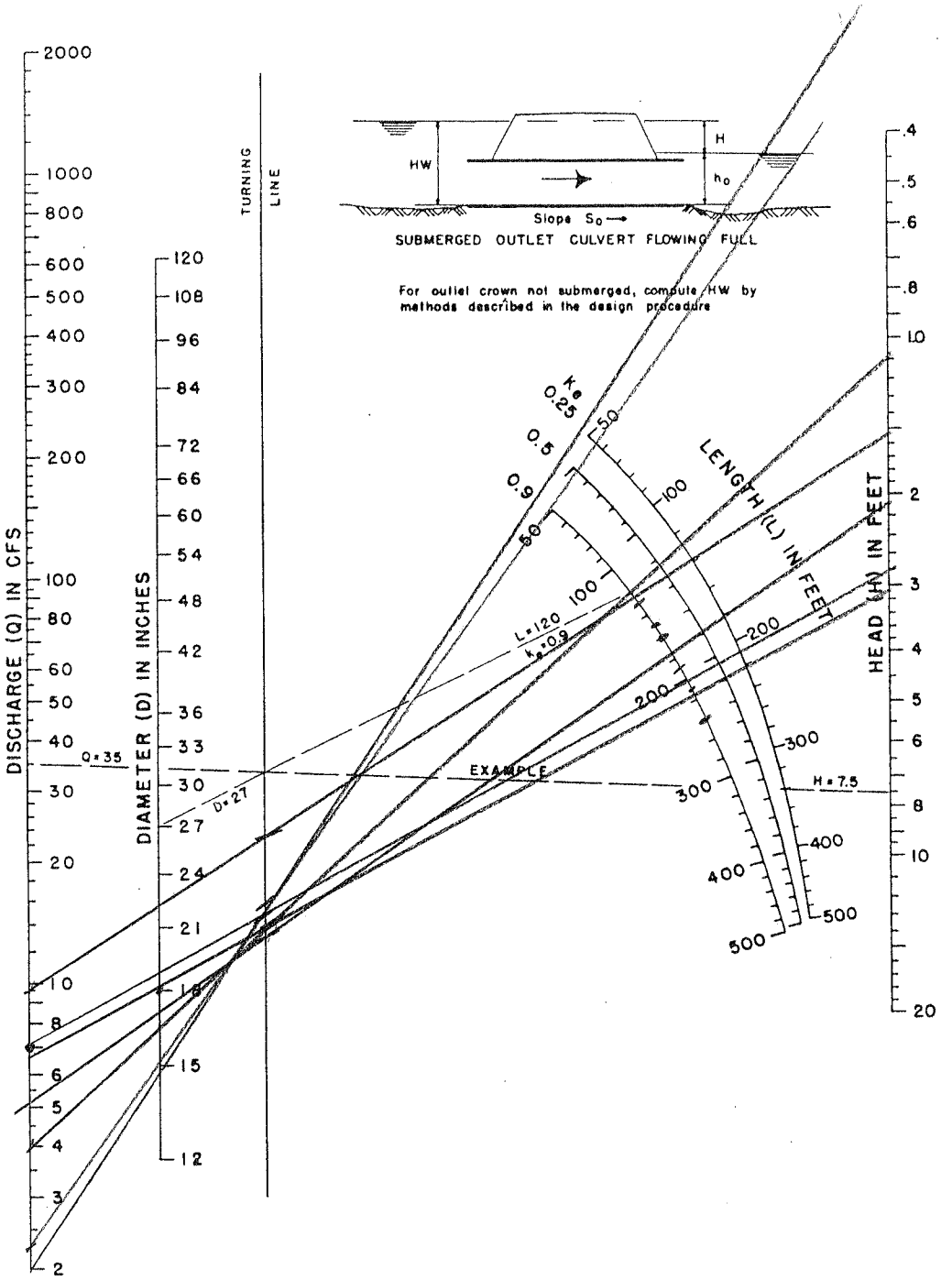


HEAD FOR
STANDARD
C. M. PIPE CULVERTS
FLOWING FULL
n = 0.024

BUREAU OF PUBLIC ROADS JAN. 1963

PROJECT Johnston County CDLF Expansion

SUBJECT Outlet Protection Analysis

SHEET 1 OF 3
JOB NO. JOHNSTON-21
DATE 12/8/03
COMPUTED BY PKS
CHECKED BY

Objective

To design rip-rap aprons at the outlet of facility culverts and sediment basin barrel pipes to handle the maximum flow from the design storm. The maximum flow for each pipe was calculated in culvert and/or sedimentation basin calculations.

Reference

North Carolina Erosion & Sediment Control Planning & Design Manual, North Carolina Division of Land Resources, 1988.

Analysis

The following approach, based on Section 8.06 of the NC Erosion & Sediment Control Planning and Design Manual, is used to properly size rip-rap aprons:

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.

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)

OUTLETPROTECT.WPD

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

G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2 / 3
JOB #: JOHNSTON-21
DATE: 12/8/03
BY: PKS
CHKD BY:

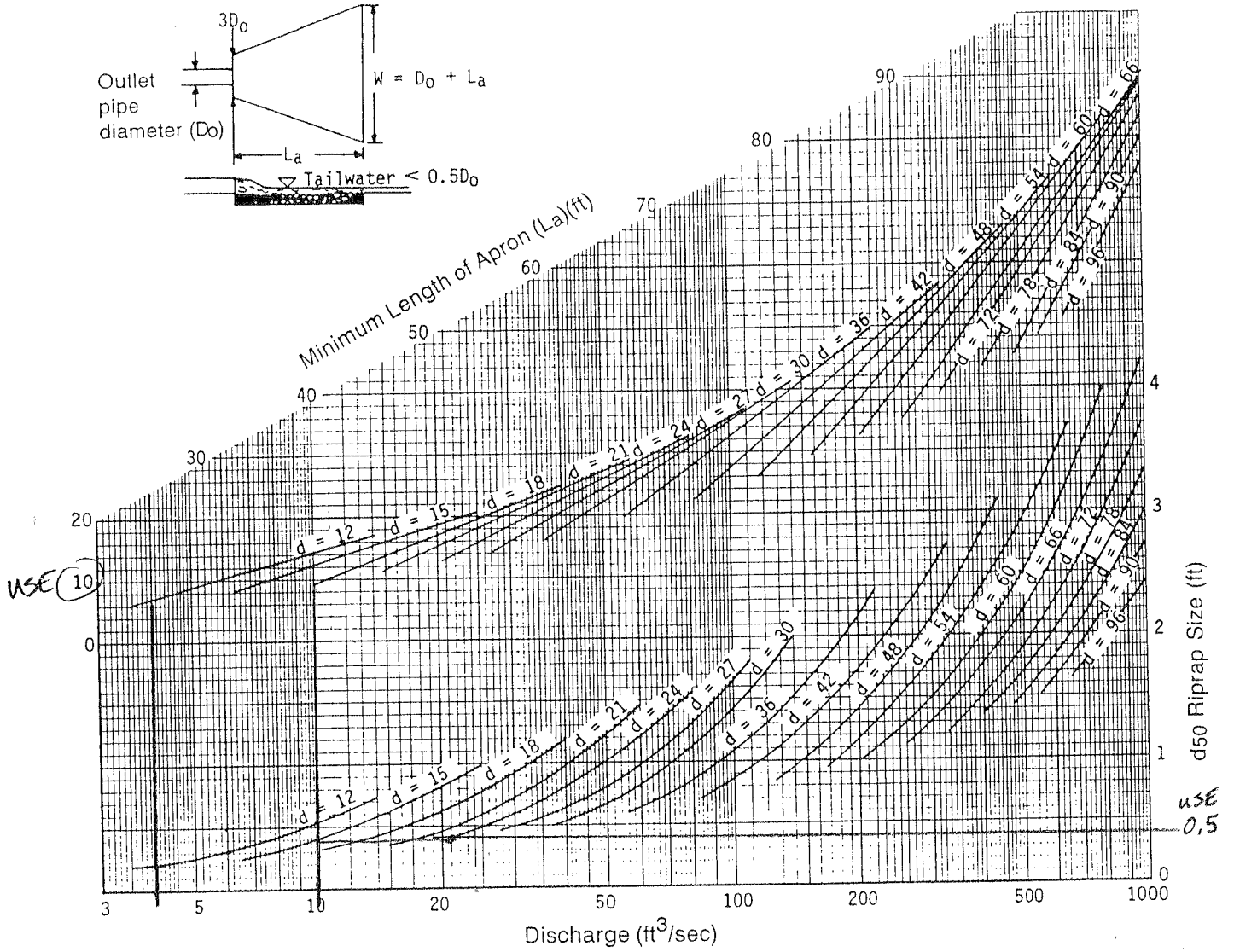
Johnston County Landfill - CDLF Expansion
Outlet Protection Analysis

Rip-Rap Apron Design:

(User Input) Outlet	(User Input) Diameter (inches)	(User Input) Design Flow (cfs)	(User Input) Tailwater Condition	(User Input) d50 (feet)	dmax (feet)	Thickness (feet) (No Geotextile)	Thickness (feet) (w/ Geotextile)	(User Input) La (feet)	W (feet)
Down Pipe No. 3A	24	10.0	Tw < 0.5Do	0.5	0.8	1.1	0.8	10	12
Down Pipe No. 4	18	4.0	Tw < 0.5Do	0.5	0.8	1.1	0.8	10	12

OUTLETPROTECT.WB3

3/3



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).

Attachment E

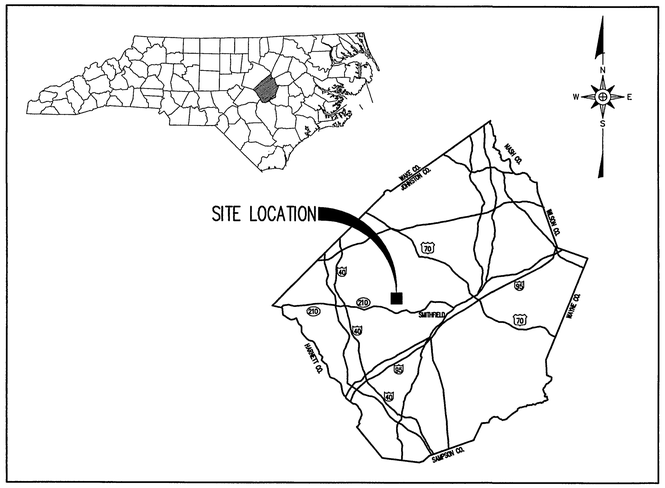
Permit Modification Drawings

Permit:	51-03
Name:	Johnston County MSW Landfill
County:	Johnston
Shipped Date:	
Box:	SW-11-028
Document Type:	Other (O)
Document Date:	8/1/2005
Division:	Waste Management (WM)
Sub-Division:	Solid Waste (SW)
Document Category:	Facility (F)
Document Group:	Authorization or Permit (P)
Description:	Map: . Maps in Roll: 8

JOHNSTON COUNTY, NORTH CAROLINA
DEPARTMENT OF PUBLIC UTILITIES

C & D LANDFILL VERTICAL EXPANSION
PERMIT MODIFICATION

DECEMBER 2003



VICINITY MAP
NOT TO SCALE

SHEET	DRAWING	TITLE
1	1	TITLE/COVER SHEET
2	S1	EXISTING SITE CONDITIONS
3	S2	C & D LANDFILL VERTICAL EXPANSION FINAL COVER PLAN
4	EC1	EROSION & SEDIMENT CONTROL PLAN
5	G1	DETAILS – SHEET 1 OF 2
6	G2	DETAILS – SHEET 2 OF 2
7	X1	CROSS SECTIONS
8	P1	C & D LANDFILL PHASING PLAN

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NORTH CAROLINA PROFESSIONAL SEAL 021686 ENGINEER PIETER K. SCHEER 12/12/03

FILE NAME JOHN-D0300

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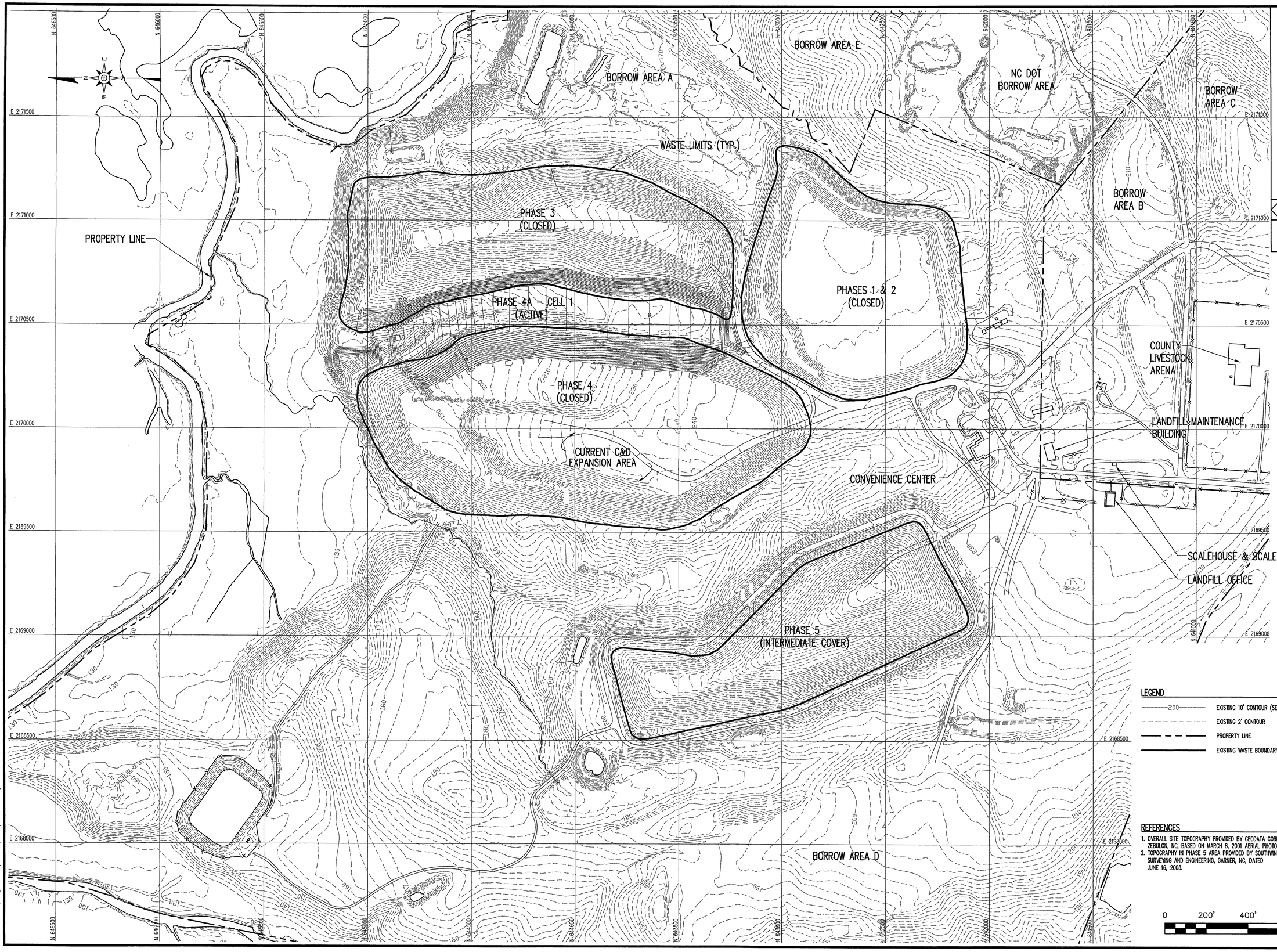

LEGEND

- 200 — EXISTING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- PROPERTY LINE
- EXISTING WASTE BOUNDARY

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORPORATION, ZEBULON, NC, BASED ON MARCH 8, 2001 AERIAL PHOTOGRAPHY.
2. TOPOGRAPHY IN PHASE 5 AREA PROVIDED BY SOUTHWIND SURVEYING AND ENGINEERING, GARNER, NC, DATED JUNE 16, 2003.

0 200' 400' 600'

C:\CAD\JOHNSTON\John-21\sheets\JOHN-D0301.dwg DATE: DEC 09, 2003 TIME: 3:06 PM

REVISION	NO.	DATE

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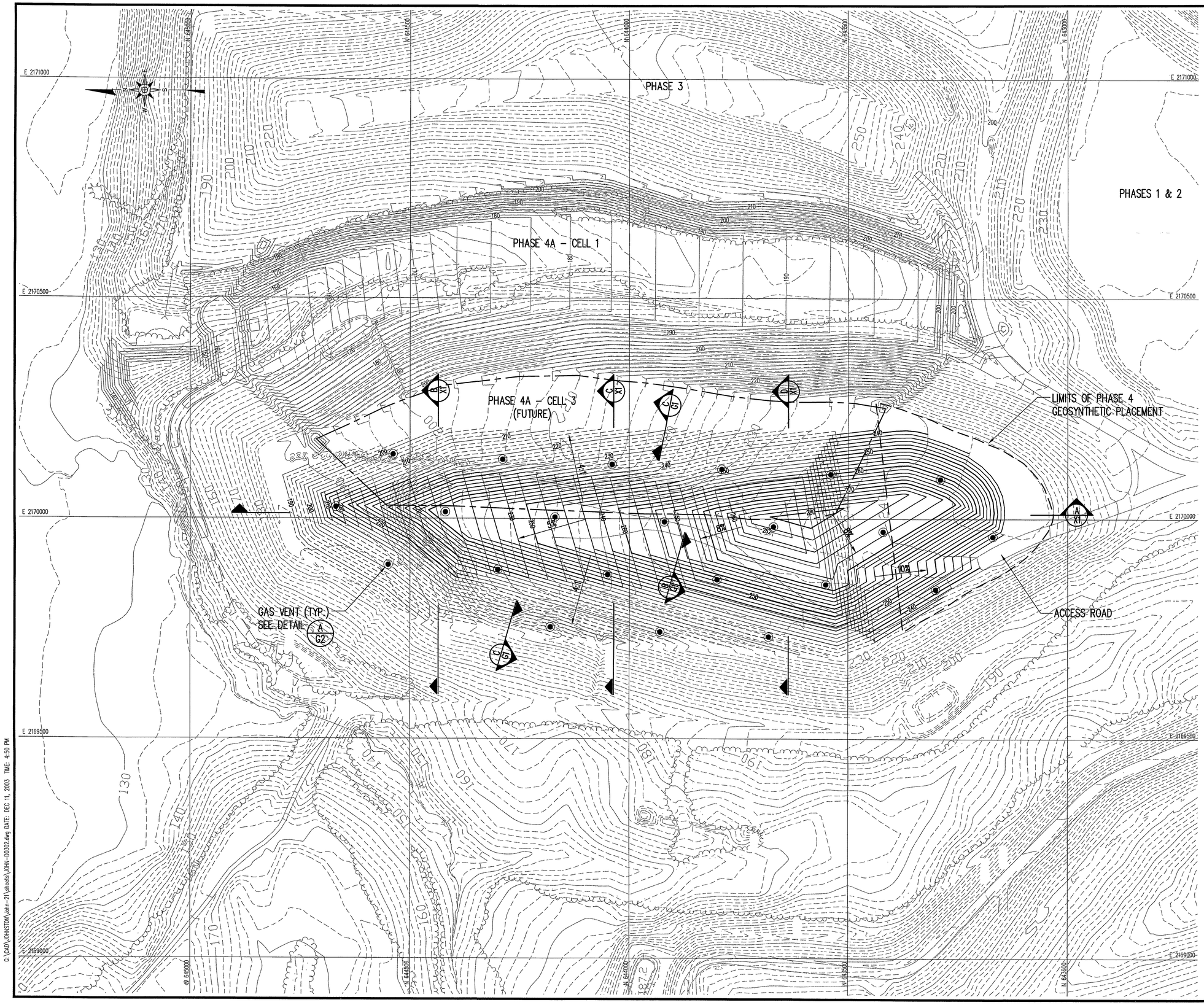
SEAL

NORTH CAROLINA PROFESSIONAL SEAL 021686 ENGINEER PETER K. SOSSOU 2/12/04

PROJECT TITLE:
JOHNSTON COUNTY
C & D LANDFILL
VERTICAL EXPANSION
PERMIT MODIFICATION

DRAWING TITLE:
EXISTING SITE CONDITIONS

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY:	PROJECT NO.:
G.N.R.	JOHN-21
SCALE:	DATE:
AS SHOWN	DEC. 2003
FILE NAME	
JOHN-D0301	
SHEET NO.	DRAWING NO.
2	S1



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NO.	DATE	REVISION

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SEAL

SEAL
NORTH CAROLINA PROFESSIONAL SEAL 021668 ENGINEER PETER K. SPEARS

PROJECT TITLE:
JOHNSTON COUNTY
C & D LANDFILL
VERTICAL EXPANSION
PERMIT MODIFICATION

DRAWING TITLE:
C & D LANDFILL
VERTICAL EXPANSION
FINAL COVER PLAN

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY:	PROJECT NO.:
G.N.R.	JOHN-21
SCALE:	DATE:
AS SHOWN	DEC. 2003
FILE NAME	
JOHN-D0302	
SHEET NO.	DRAWING NO.
3	S2

PHASE 3

PHASES 1 & 2

PHASE 4A – CELL 1

EXISTING SEDIMENT BASIN NO. 5A

EXISTING CULVERT (2 x 24"ø CPE)

EXISTING DRAINAGE CHANNEL

EXISTING DRAINAGE CHANNEL

DIVERSION BERM SEE DETAIL D / G1

CAP DIVERSION BERM SEE DETAIL B / G1

FILTER BERM (TYP.) SEE DETAIL E / G1

RIPRAP OUTLET PROTECTION SEE DETAIL F / G1

EXISTING SEDIMENT BASIN NO. 2

DRAINAGE CHANNEL (TYP.) SEE DETAIL C / G1

EXISTING SEDIMENT BASIN NO. 1

ACCESS ROAD

E 2171000 E 2170500 E 2170000 E 2169500 E 2169000

N 645500 N 644000 N 644500 N 643500 N 643000

DOWN PIPE SCHEDULE				
DOWN PIPE NO.	SIZE/TYPE	LENGTH	INV. IN	INV. OUT
DP-1 (EXISTING)	18"ø CPE (TYPE C)	160'	232.0	194.0
DP-2 (EXISTING)	18"ø CPE (TYPE C)	150'	208.0	178.0
DP-3 (EXISTING)	18"ø CPE (TYPE C)	210'	185.0	142.0
DP-3A	24"ø CPE (TYPE C)	200'	185.0	142.0
DP-4	18"ø CPE (TYPE C)	190'	240.0	200.0
DP-5	18"ø CPE (TYPE C)	130'	271.0	241.0
DP-6	18"ø CPE (TYPE C)	240'	241.0	186.0

LEGEND

- 200 — EXISTING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- 270 — PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR
- DC-1 — CHANNEL
- DB — DIVERSION BERM
- CDB — CAP DIVERSION BERM
- DP-3A — DOWN PIPE
- DP-1 — EXISTING DOWN PIPE

NOTES

1. C&D CONTOURS SHOWN REPRESENT TOP OF FINAL COVER.

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORPORATION, ZEBULON, NC, BASED ON MARCH 8, 2001 AERIAL PHOTOGRAPHY.
2. TOPOGRAPHY IN PHASE 5 AREA PROVIDED BY SOUTHWIND SURVEYING AND ENGINEERING, GARNER, NC, DATED JUNE 16, 2003.

0 100' 200' 300'

NO.	DATE	REVISION

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Engineering and Geological Services
14 N. BOYLAN AVENUE RALEIGH, N.C. 27603
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SEAL

SEAL

PROJECT TITLE: JOHNSTON COUNTY C & D LANDFILL VERTICAL EXPANSION PERMIT MODIFICATION

DRAWING TITLE: EROSION AND SEDIMENT CONTROL PLAN

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY:	PROJECT NO.:
G.N.R.	JOHN-21
SCALE:	DATE:
AS SHOWN	DEC. 2003
FILE NAME	
JOHN-D0303	
SHEET NO.	DRAWING NO.
4	EC1

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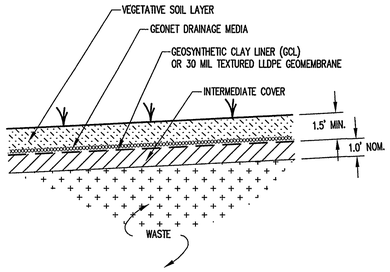
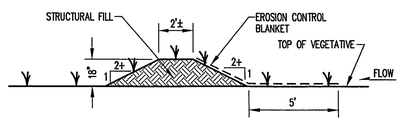


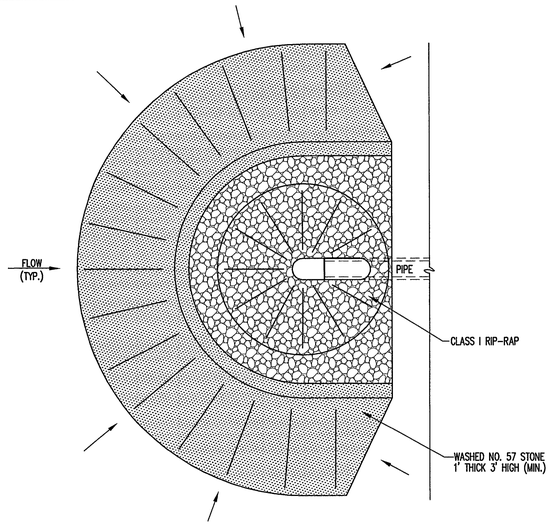
FINAL COVER CROSS SECTION

DETAIL A G1 — NOT TO SCALE

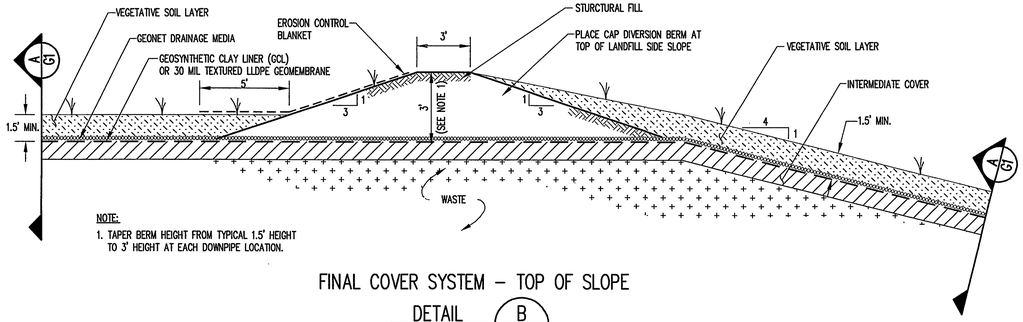


DIVERSION BERM

DETAIL D G1 — SCALE: 1"= 4'



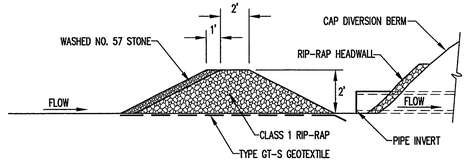
PLAN VIEW



NOTE:
1. TAPER BERM HEIGHT FROM TYPICAL 1.5' HEIGHT TO 3' HEIGHT AT EACH DOWNPIPE LOCATION.

FINAL COVER SYSTEM – TOP OF SLOPE

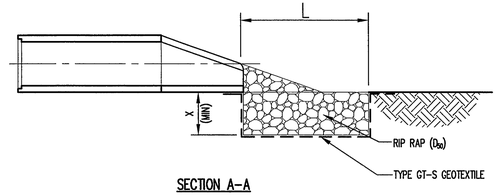
DETAIL B G1 — SCALE: 1"= 4'-0"



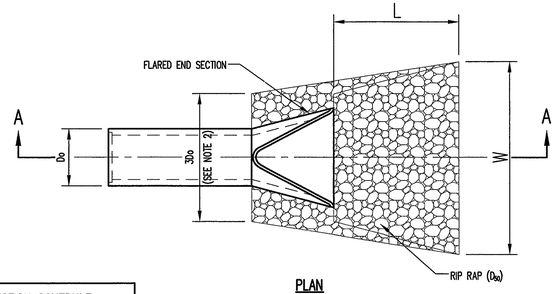
SECTION

FILTER BERM

DETAIL E G1 — N.T.S.



SECTION A-A



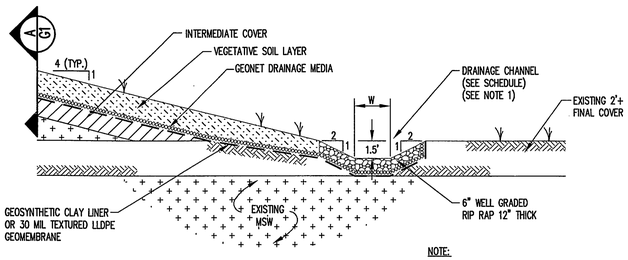
PLAN

RIP RAP OUTLET PROTECTION

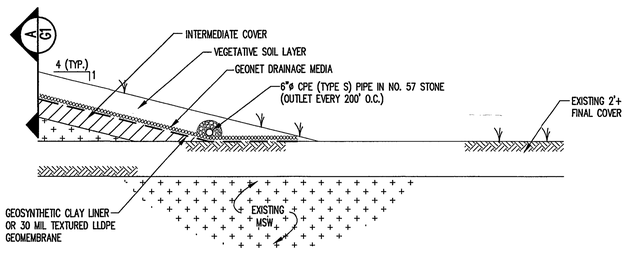
DETAIL F G1 — N.T.S.

RIP RAP OUTLET PROTECTION SCHEDULE					
PIPE	D_0	L	W	X	D_{50}
DP-3A	24"	10'	12'	1.0'	6"
DP-4	18"	10'	12'	1.0'	6"

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.



WITH DRAINAGE CHANNEL



WITHOUT CHANNEL

NOTE:
1. WHEN WASTE IS ENCOUNTERED UNDER DRAINAGE CHANNEL, OVEREXCAVATE 12" AND BACKFILL WITH STRUCTURAL FILL.

CHANNEL SCHEDULE	
CHANNEL	W (FEET)
DC-1	0
DC-2	0
DC-3	0
DC-4	0
DC-5	0
DC-6	0
DC-7	SEE DETAIL D G1

FINAL COVER SYSTEM – BASE OF SLOPE

DETAIL C G1 — SCALE: 1"= 4'-0"

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NO.	DATE	REVISION

SEAL

PROJECT TITLE:
JOHNSTON COUNTY
C & D LANDFILL
VERTICAL EXPANSION
PERMIT MODIFICATION

DRAWING TITLE:
DETAILS (SHEET 1 OF 2)

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY:	PROJECT NO.:
G.N.R.	JOHN-21
SCALE:	DATE:
AS SHOWN	DEC. 2003
FILE NAME	
JOHN-D0306	
SHEET NO.	DRAWING NO.
5	G1

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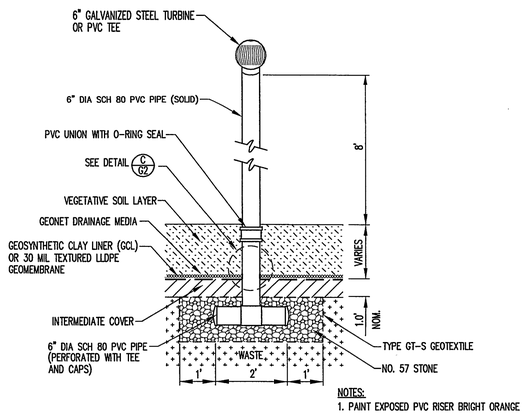
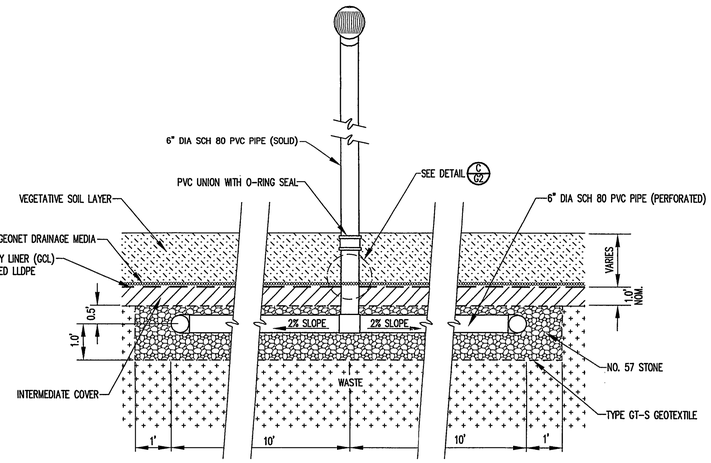


NOTES:
1. PAINT EXPOSED PVC RISER BRIGHT ORANGE

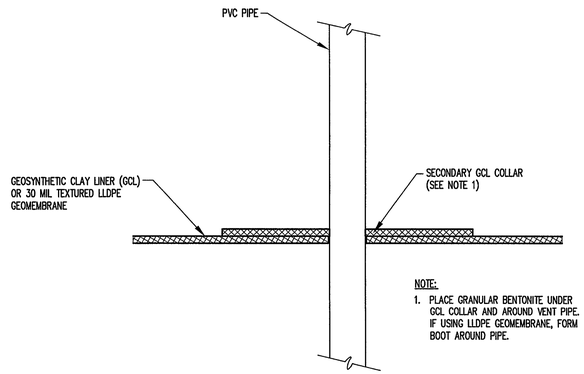
TYPICAL END VIEW OF GAS VENT

DETAIL A/G2 N.T.S.



TYPICAL SIDE VIEW OF GAS VENT

DETAIL B/G2 N.T.S.



NOTE:
1. PLACE GRANULAR BENTONITE UNDER GCL COLLAR AND AROUND VENT PIPE. IF USING LLDPE GEOMEMBRANE, FORM BOOT AROUND PIPE.

TYPICAL GAS VENT GEOSYNTHETIC PENETRATION

DETAIL C/G2 N.T.S.

NO.	DATE	REVISION

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SEAL

SEAL 021666 ENGINEER PIETER K. STRAUSS 12/12/03

PROJECT TITLE:
JOHNSTON COUNTY
C & D LANDFILL
VERTICAL EXPANSION
PERMIT MODIFICATION

DRAWING TITLE:
DETAILS (SHEET 2 OF 2)

DESIGNED BY:	DRAWN BY:
P.K.S.	C.T.J.
CHECKED BY:	PROJECT NO.:
G.N.R.	JOHN-21
SCALE:	DATE:
AS SHOWN	DEC. 2003
FILE NAME	
JOHN-D0307	
SHEET NO.	DRAWING NO.
6	G2

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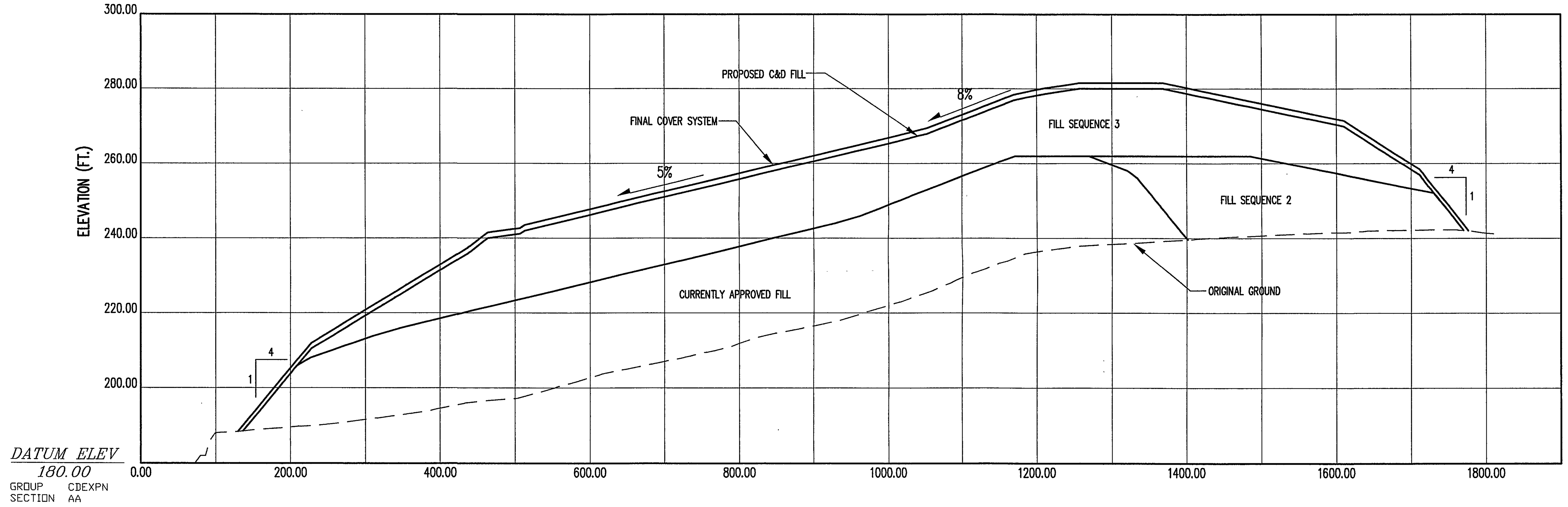
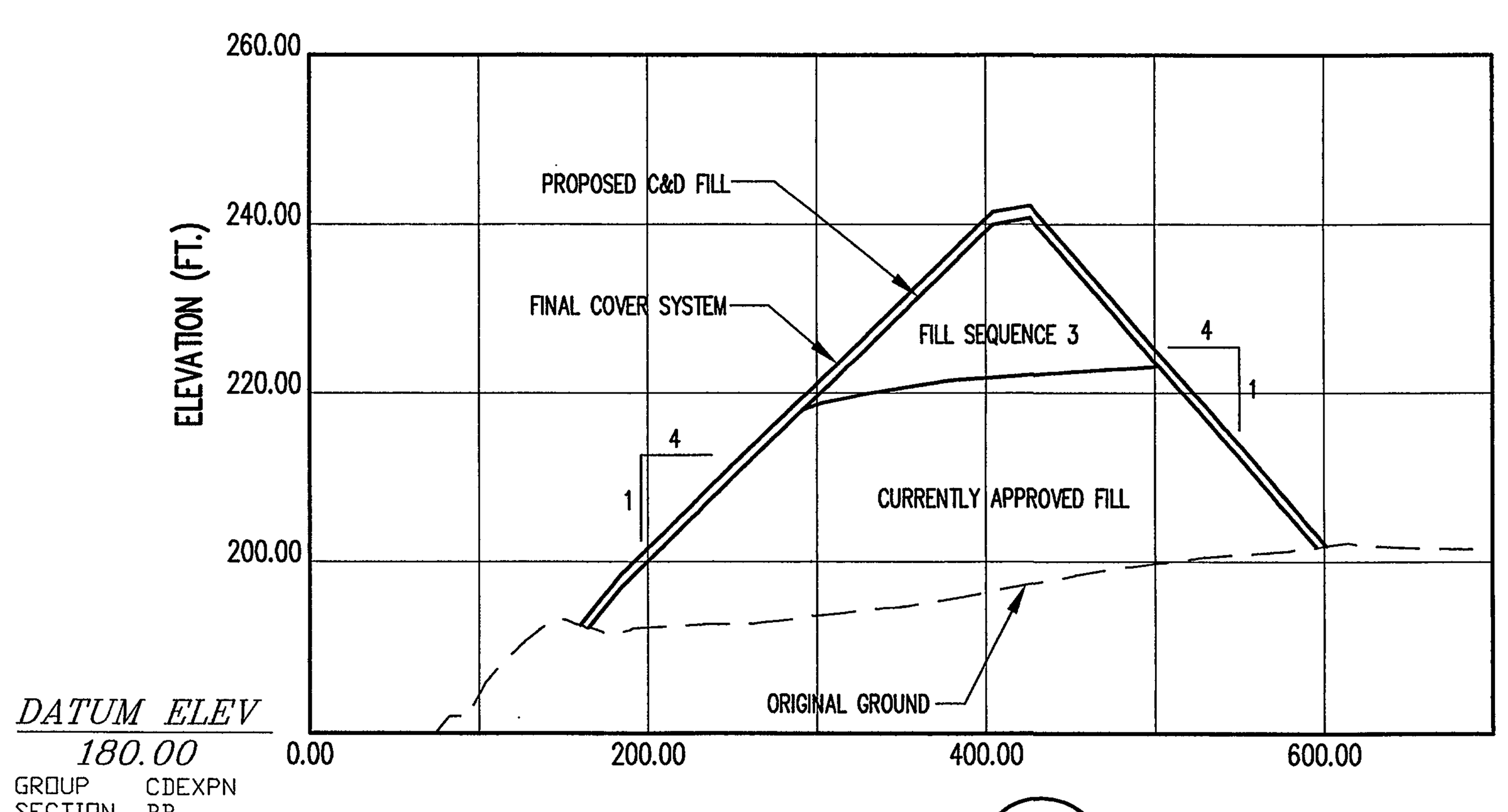


SECTION A / X1



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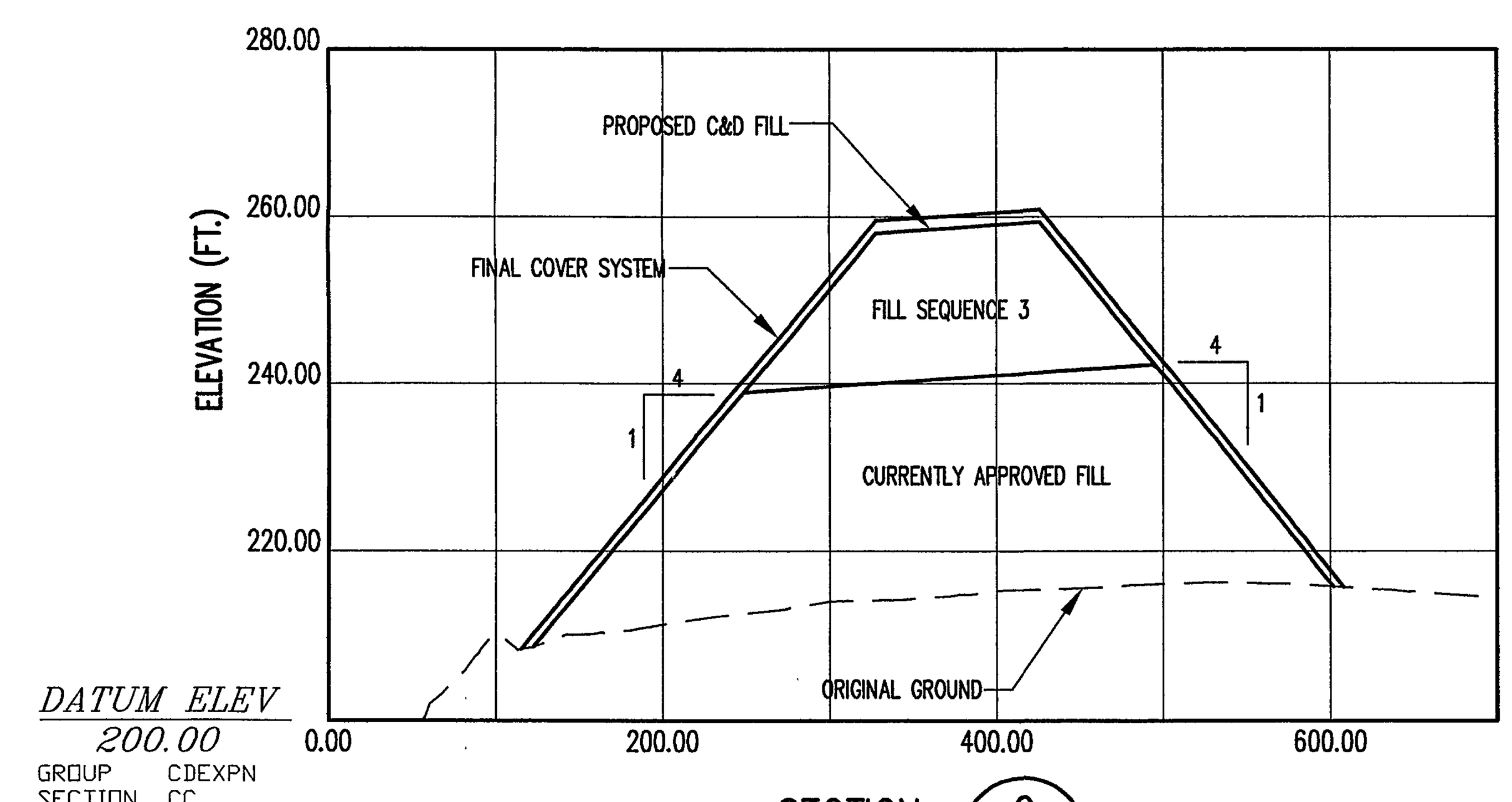

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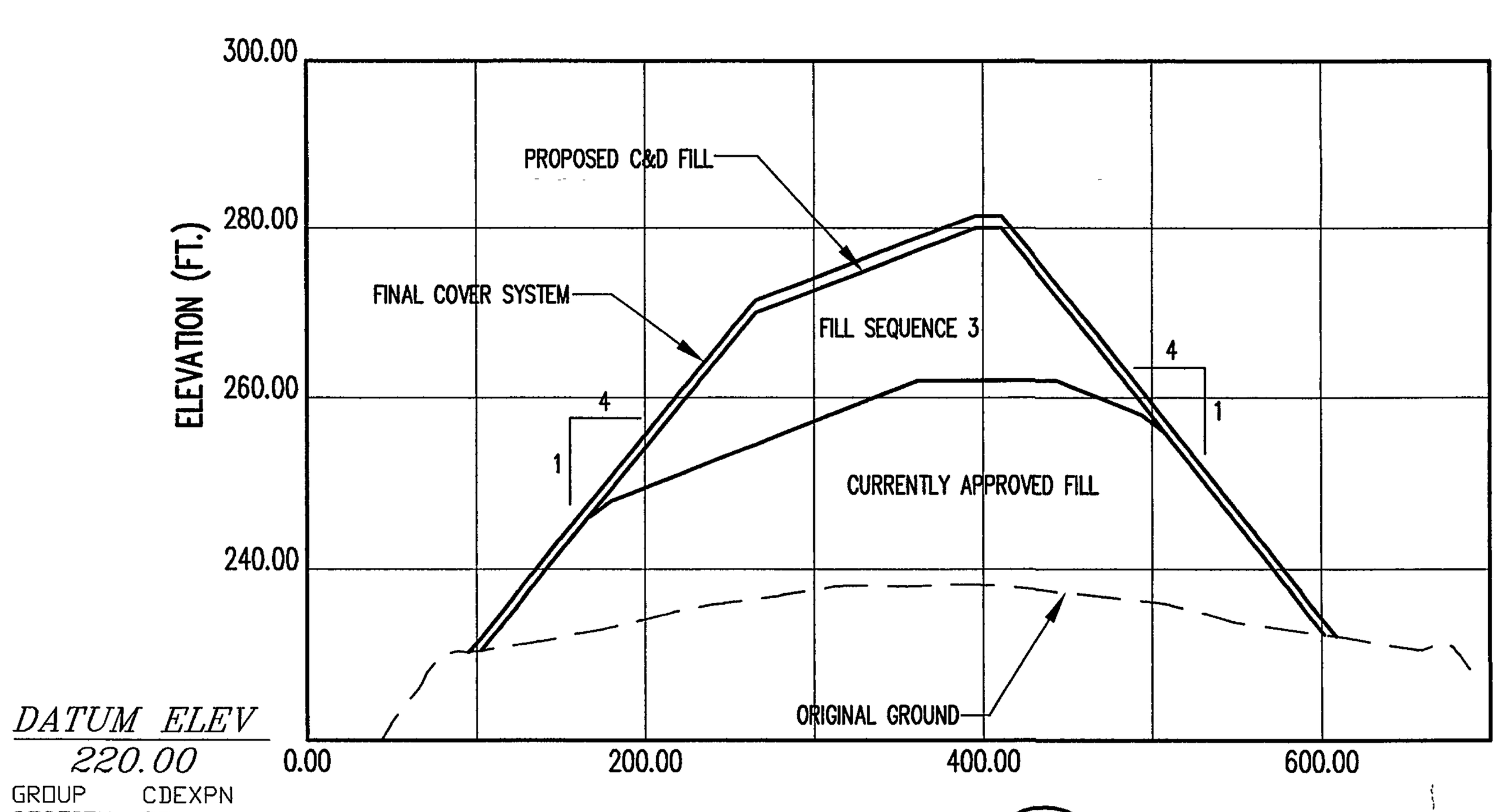

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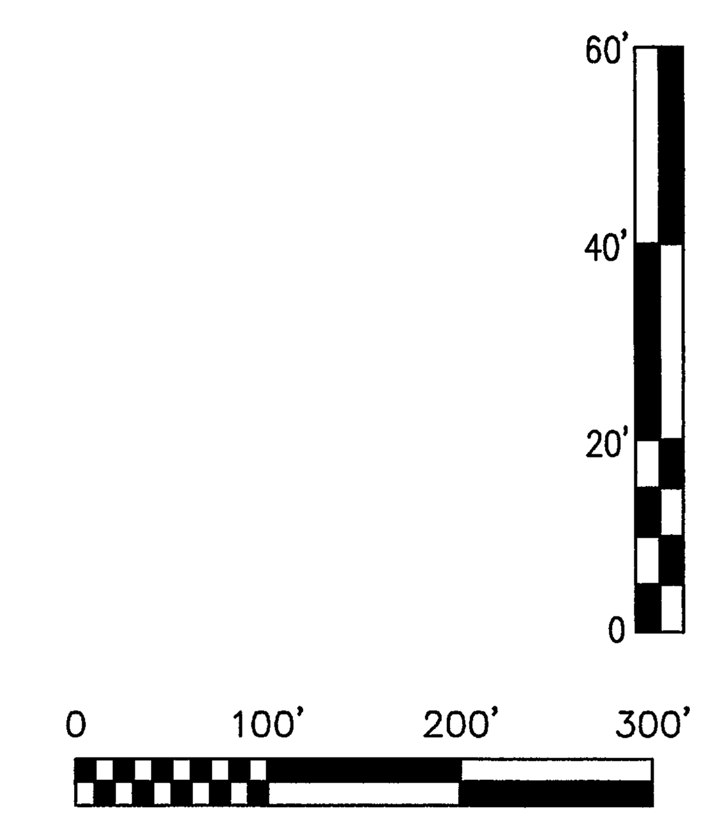

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DATE	NO.	REVISION

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services
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SEAL

PROFESSIONAL ENGINEER SEAL 021066 PIETER K. SCHEER 12/12/03

PROJECT TITLE:

JOHNSTON COUNTY
C & D LANDFILL
VERTICAL EXPANSION
PERMIT MODIFICATION

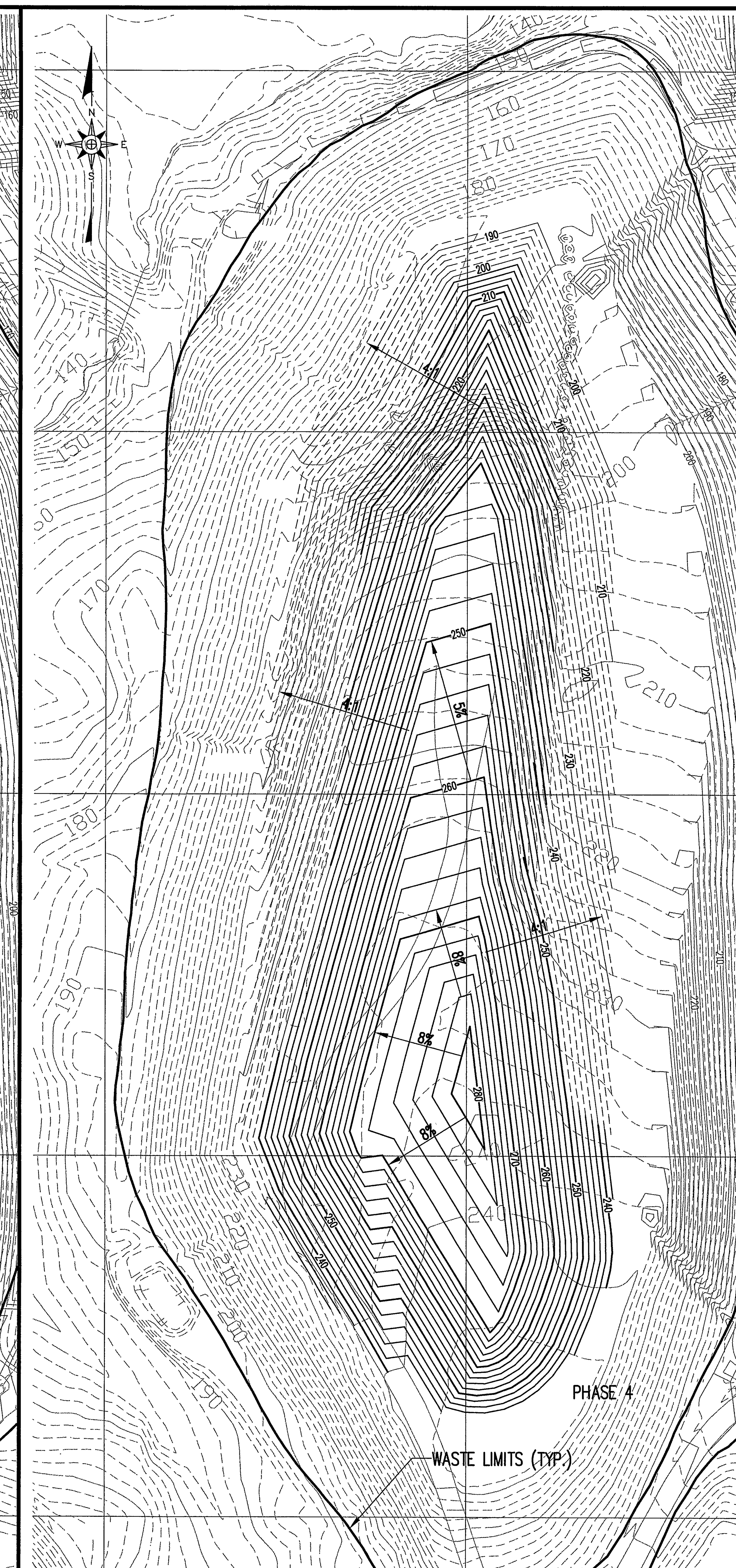
DRAWING TITLE:

CROSS SECTIONS

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: G.N.R.	PROJECT NO.: JOHN-21
SCALE: AS SHOWN	DATE: DEC. 2003
FILE NAME: JOHN-D0304	
SHEET NO.: 7	DRAWING NO.: X1

C&D LANDFILL – FILL SEQUENCE 1 (CURRENTLY APPROVED)

C&D LANDFILL – FILL SEQUENCE 2



C&D LANDFILL – FILL SEQUENCE 3

0 100' 200' 300'

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14 N. BOYLAN AVENUE RALEIGH, N.C. 27603
PHONE-919-828-0577 FAX-919-828-3899 WWW.GNRA.COM

PROJECT TITLE: JOHNSTON COUNTY C & D LANDFILL VERTICAL EXPANSION PERMIT MODIFICATION

DRAWING TITLE: C & D LANDFILL PHASING PLAN

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY: G.N.R.	PROJECT NO.: JOHN-21
SCALE: AS SHOWN	DATE: DEC. 2003
FILE NAME: JOHN-D0305	
SHEET NO. 8	DRAWING NO. P1

G:\CAD\JOHNSTON\John-21\sheets\JOHN-D0305.dwg DATE: DEC 11, 2003 TIME: 3:58 PM