SMITH+GARDNER
ENGINEERS

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September 29, 2016

Mr. Edward F. Mussler, III, P.E.
Permitting Branch Head
NC DEQ Division of Waste Management
217 W. Jones Street
Raleigh, NC 27603

RE: Davidson County C&D Landfill (Permit No. 29-06)
Notification of Intent to Close
Request for Alternative Final Cover System
Request for Extension of Period for Closure

Dear Ed:

On behalf of Davidson County, Smith Gardner, Inc. (S+G) is submitting this letter to:

1) Notify the NC Department of Environmental Quality Division of Waste Management (DWM) that the County intends to close their construction and demolition debris (C&D) landfill;
2) Request approval of an alternative final cover system for the C&D landfill; and
3) Provide an anticipated schedule for completion of the work.

Based on the work involved and allowance for some weather delays, the County requests extension of the period for closure until May 15, 2017 following 15A NCAC 13B.0543 (c) (6).

Notification of Intent to Close

The County ceased disposal of waste in the C&D landfill unit on June 15, 2016, which was before the permit to operate expired on July 18, 2016. Since then, the County has performed additional grading and cover activities, preparing the landfill for closure and addressing comments based on recent inspections by DWM. Note that these activities are anticipated to prevent threats to human health and the environment until all closure activities can be completed (see schedule for completion below). Additionally, S+G has been preparing plans and specifications for the bidding and construction of the closure, which will be performed by a qualified contractor.

This letter serves as formal notification of the intent to close (.0543 (c) (4)) and a copy will be placed in the operating record.

Alternative Final Cover System

As part of the preparation for the closure of the C&D landfill, S+G reviewed options for closure to both optimize the use of available soil resources in the vicinity of the C&D landfill (portion of facility south of railroad tracks)and which would result in an equal or improved performance. Based on this, the following final cover system is proposed as an alternative to the previously approved regulatory final cover system (.0543 (c) (1)) for the C&D landfill (components listed top-down):

Alternative Final Cover System (.0543 (c)(3)):

Top Slopes (Typically 5 to 8%):

- a 24-inch thick vegetative soil layer;
- a drainage geocomposite;
- a 30-mil textured LLDPE geomembrane or geosynthetic clay liner (GCL); and
- a 12-inch thick intermediate cover layer.

Side Slopes (Typically 3 or 4H:1V):

- a 24-inch thick vegetative soil layer.

Surface water control devices and landfill gas (LFG) wells/vents will also be incorporated into the final cover system very much the same as the previously approved design[1]. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications.

The following calculations are provided in **Attachment A** relative to the proposed alternative final cover system:

1. Final Cover Infiltration Analysis: This analysis was performed to demonstrate that the proposed alternative final cover system allows no more infiltration than the previously approved regulatory final cover system. The results of the calculations show that the proposed alternative final cover system will actually allow less infiltration and, thus, is expected to provide improved performance over the regulatory final cover system.

2. Final Cover Drainage Layer Analysis: This analysis focused on determining the required transmissivity to maintain the peak head within the drainage geocomposite.

3. Filter Geotextile Analysis: This analysis shows that the upper geotextile of the drainage geocomposite is expected to perform acceptably as a filter when covered with typical site soils.

[1] Richardson Smith Gardner & Assocs., Inc. (2011), Permit Amendment Application - Davidson County C&D Landfill - Phases 3 & 4, April 2009, Revised April 2011.

4. Veneer Stability Analysis: This analysis shows that the final cover system utilizing geosynthetics (top slopes) will be stable under anticipated loading conditions.

Note that the proposed alternative final cover system is very similar to alternative final cover systems approved for other C&D landfills in North Carolina.

Technical specifications, a construction quality assurance (CQA) manual, and drawings for the closure project are provided in **Attachments B, C, and D**, respectively. These documents include information related to both the previously approved and proposed alternative final cover systems.

It is currently anticipated that the County will bid the regulatory and alternative final cover systems as alternates during the upcoming bid process. In order to proceed with the bidding of the project without potential significant changes, S+G would like to discuss the proposed alternative final cover system with you at your earliest convenience.

Schedule for Completion

The currently anticipated schedule for completion of the closure work is as follows:

Finalize Bid Documents and Issue for Bids: October 2016
Receive Bids: November 2016
Award Project: December 13th BOC Mtg.
Start Construction: January 2017
Completion of Construction: April 2017 (Assumes 100 Day Schedule)

To allow for potential weather delays during construction of the final cover system, the County requests extension of the period for closure until May 15, 2017.

Please contact us at your earliest convenience should you have any questions or comments or if you require additional information related to this submittal.

Sincerely,
SMITH GARDNER, INC.

Gregory G. Mills, P.E.
Senior Project Engineer
gregm@smithgardnerinc.com

Pieter K. Scheer, P.E.
Vice President, Senior Engineer
pieter@smithgardnerinc.com

Attachments: Attachment A: Calculations
Attachment B: Technical Specifications
Attachment C: CQA Manual
Attachment D: Closure Drawings

cc: Rex Buck, Davidson County
Steven Sink, Davidson County
Susan Heim, NC DEQ - DWM

Attachment A

Calculations

Alternative Final Cover System Request
Davidson County C&D Landfill
Davidson County, North Carolina

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Alternative Final Cover System Request
Attachment A: Calculations

Table of Contents

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SMITH+GARDNER

ADDRESS 14 N. Boylan Avenue, Raleigh, NC 27603

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WEB www.smithgardnerinc.com

PROJECT Davidson County C&DLF SHEET 1 OF 22 DATE 9/6/2016

COMPUTED BY PKS

SUBJECT Final Cover Infiltration Analysis JOB # DAVDCO-16-12 CHECKED BY GGM

OBJECTIVE:

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

REFERENCES:

Berger, Klaus (2012), "Engineering Documentation for HELP 3.95D - Enhancements Beyond HELP 3.07," Institute of Soil Science, University of Hamburg, Hamburg, Germany.

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

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

ANALYSIS:

Final Cover Systems Analyzed:

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

A. 24 inches Vegetative Soil Layer
B. Drainage Geocomposite
C. 30 mil Textured LLDPE Geomembrane or Geosynthetic Clay Liner (GCL)
D. 12 inches Intermediate Cover

1B. Proposed Final Cover System (Side Slopes - 3 or 4H:1V):

A. 24 inches Vegetative Soil Layer

2. Regulatory Final Cover System: (Top Down)

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

RESULTS:

Case	Slope of Final Cover System (%)	Average Annual Infiltration (inches)
1A-1 (GM)	5	0.002
1A-2 (GCL)	5	0.03
1B (Soil)	25	10.7
2A (RMC)	5	11.1
2B (RMC)	25	11.1

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

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 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                                                                          **
 **              HELP Version 3.95 D          (10 August 2012)              **
 **                                developed at                              **
 **        Institute of Soil Science, University of Hamburg, Germany         **
 **                                  based on                                **
 **              US 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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 TIME:   9.26     DATE:   6.09.2016

 PRECIPITATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d4
 TEMPERATURE DATA FILE:
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 SOLAR RADIATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d13
 EVAPOTRANSPIRATION DATA F. 1:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d11
 SOIL AND DESIGN DATA FILE  1:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC1A1.d10
 OUTPUT DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC1A1.out

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

     TITLE:  Davidson County C&DLF - Case 1A-1 (GM - Top Slopes)

 ******************************************************************************
                          WEATHER DATA SOURCES
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         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA

                    NORMAL MEAN MONTHLY PRECIPITATION (MM)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       89.2        85.6        98.6        80.3        85.6        99.8
      108.5       106.4        92.5        80.8        65.8        85.9

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

                NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       3.1         4.4         8.9        14.6        19.2        23.1
      25.1        24.6        21.1        14.7         9.2         4.6

         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA
                    AND STATION LATITUDE  =  35.13 DEGREES

 ******************************************************************************
                                LAYER DATA   1
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                              VALID FOR  20 YEARS

       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  10
    THICKNESS                     =     24.00   INCHES
    POROSITY                      =      0.3980 VOL/VOL
    FIELD CAPACITY                =      0.2440 VOL/VOL
    WILTING POINT                 =      0.1360 VOL/VOL
    INITIAL SOIL WATER CONTENT    =      0.2872 VOL/VOL
    EFFECTIVE SAT. HYD. CONDUCT.=      0.1200E-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    =      0.0167 VOL/VOL
    EFFECTIVE SAT. HYD. CONDUCT.=       10.00     CM/SEC
    SLOPE                         =      5.00   PERCENT
    DRAINAGE LENGTH               =    100.0    FEET
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LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.03	INCHES
EFFECTIVE SAT. HYD. CONDUCT.	=	0.4000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	8.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1200E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA 1

VALID FOR 20 YEARS

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 100. FEET.

SCS RUNOFF CURVE NUMBER	=	76.72	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.001	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.358	INCHES
FIELD CAPACITY OF EVAPORATIVE ZONE	=	5.124	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.856	INCHES
SOIL EVAPORATION ZONE DEPTH	=	21.000	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL INTERCEPTION WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.826	INCHES
TOTAL INITIAL WATER	=	9.826	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION DATA 1

VALID FOR 20 YEARS

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GREENSBORO NORTH CAROLINA

STATION LATITUDE	=	35.13	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	90	
END OF GROWING SEASON (JULIAN DATE)	=	305	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	12.23	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.0	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.0	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.0	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.0	%

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	6.9977	0.2916
2	0.0096	0.0384
3	0.0000	0.0000
4	2.9280	0.2440
TOTAL WATER IN LAYERS	9.935	
SNOW WATER	0.000	
INTERCEPTION WATER	0.000	
TOTAL FINAL WATER	9.935	

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	4.09	14834.409
RUNOFF	1.045	3791.7039
DRAINAGE COLLECTED FROM LAYER 2	1.19850	4350.56494
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000174	0.63235
AVERAGE HEAD ON TOP OF LAYER 3	0.171	
MAXIMUM HEAD ON TOP OF LAYER 3	0.085	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000174	0.63235
SNOW WATER	2.44	8868.2080
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3587	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

*** 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.

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.65	3.20	4.03	2.75	3.16	3.95
	4.76	5.08	4.02	2.49	2.59	3.86
STD. DEVIATIONS	1.66	1.36	1.92	1.36	1.26	2.48
	2.00	2.45	2.47	1.67	1.94	1.87
RUNOFF						
TOTALS	0.020	0.028	0.054	0.019	0.006	0.065
	0.056	0.079	0.167	0.083	0.041	0.074
STD. DEVIATIONS	0.044	0.076	0.107	0.056	0.024	0.233
	0.143	0.171	0.282	0.166	0.170	0.172
POTENTIAL EVAPOTRANSPIRATION						
TOTALS	2.332	2.517	4.152	5.610	7.169	7.926
	7.863	6.997	5.381	4.069	2.826	2.059
STD. DEVIATIONS	0.215	0.312	0.299	0.318	0.321	0.348
	0.286	0.269	0.301	0.255	0.230	0.177
ACTUAL EVAPOTRANSPIRATION						
TOTALS	1.543	1.683	2.625	2.606	4.301	3.811
	4.496	3.961	2.311	1.401	1.372	1.265
STD. DEVIATIONS	0.257	0.314	0.477	0.544	0.766	1.809
	1.572	1.267	0.788	0.514	0.345	0.255
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7238	1.0346	1.7604	0.6261	0.2777	0.1345
	0.2272	0.3342	0.9279	1.0622	0.7574	1.5923
STD. DEVIATIONS	1.8337	0.8975	1.0744	0.7307	0.6007	0.3563
	0.5838	0.6505	1.1996	1.0692	1.1823	1.2014
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0003	0.0002	0.0003	0.0001	0.0000	0.0000
	0.0000	0.0001	0.0001	0.0002	0.0001	0.0002
STD. DEVIATIONS	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0003	0.0002	0.0003	0.0001	0.0000	0.0000
	0.0000	0.0001	0.0001	0.0002	0.0001	0.0002
STD. DEVIATIONS	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0020	0.0013	0.0020	0.0007	0.0003	0.0002
	0.0003	0.0004	0.0013	0.0012	0.0009	0.0018
STD. DEVIATIONS	0.0021	0.0011	0.0012	0.0009	0.0007	0.0004
	0.0007	0.0007	0.0021	0.0012	0.0014	0.0014

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.53 (6.833)	154391.5	100.00
RUNOFF	0.690 (0.4563)	2506.43	1.623
POTENTIAL EVAPOTRANSPIRATION	58.902 (0.8237)	213813.48	
ACTUAL EVAPOTRANSPIRATION	31.376 (3.1983)	113895.23	73.770
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.45833 (3.92454)	37963.754	24.58928
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00170 (0.00057)	6.167	0.00399
AVERAGE HEAD ON TOP OF LAYER 3	0.001 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	**0.00170 (0.00057)**	**6.167**	**0.00399**
CHANGE IN WATER STORAGE	0.005 (1.1957)	19.88	0.013

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                                                                              **
**              HELP Version 3.95 D          (10 August 2012)                   **
**                                developed at                                  **
**        Institute of Soil Science, University of Hamburg, Germany             **
**                                  based on                                    **
**              US 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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 TIME:   9.27     DATE:   6.09.2016

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 TEMPERATURE DATA FILE:
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 SOLAR RADIATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d13
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**********************************************************************************

     TITLE:  Davidson County C&DLF - Case 1A-2 (GCL - Top Slopes)

**********************************************************************************
                          WEATHER DATA SOURCES
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         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA

                    NORMAL MEAN MONTHLY PRECIPITATION (MM)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       89.2        85.6        98.6        80.3        85.6        99.8
      108.5       106.4        92.5        80.8        65.8        85.9

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

                NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       3.1         4.4         8.9        14.6        19.2        23.1
      25.1        24.6        21.1        14.7         9.2         4.6

         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA
                    AND STATION LATITUDE  =  35.13 DEGREES

**********************************************************************************
                                LAYER DATA   1
----------------------------------------------------------------------------------

                              VALID FOR  20 YEARS

        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  10
      THICKNESS                    =     24.00   INCHES
      POROSITY                     =      0.3980 VOL/VOL
      FIELD CAPACITY               =      0.2440 VOL/VOL
      WILTING POINT                =      0.1360 VOL/VOL
      INITIAL SOIL WATER CONTENT   =      0.2872 VOL/VOL
      EFFECTIVE SAT. HYD. CONDUCT.=      0.1200E-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   =      0.0167 VOL/VOL
      EFFECTIVE SAT. HYD. CONDUCT.=       10.00     CM/SEC
      SLOPE                        =      5.00   PERCENT
      DRAINAGE LENGTH              =    100.0    FEET
```

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

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. CONDUCT.	=	0.5000E-08	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1200E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA 1

VALID FOR 20 YEARS

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 100. FEET.

SCS RUNOFF CURVE NUMBER	=	76.72	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.001	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.358	INCHES
FIELD CAPACITY OF EVAPORATIVE ZONE	=	5.124	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.856	INCHES
SOIL EVAPORATION ZONE DEPTH	=	21.000	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL INTERCEPTION WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	10.013	INCHES
TOTAL INITIAL WATER	=	10.013	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION DATA 1

VALID FOR 20 YEARS

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GREENSBORO NORTH CAROLINA

STATION LATITUDE	=	35.13	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	90	
END OF GROWING SEASON (JULIAN DATE)	=	305	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	12.23	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.0	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.0	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.0	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.0	%

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	6.9977	0.2916
2	0.0096	0.0384
3	0.1875	0.7500
4	2.9280	0.2440

TOTAL WATER IN LAYERS	10.123
SNOW WATER	0.000
INTERCEPTION WATER	0.000
TOTAL FINAL WATER	10.123

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	4.09	14834.409
RUNOFF	1.045	3791.7039
DRAINAGE COLLECTED FROM LAYER 2	1.19842	4350.25732
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000249	0.90488
AVERAGE HEAD ON TOP OF LAYER 3	0.171	
MAXIMUM HEAD ON TOP OF LAYER 3	0.084	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.7 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000249	0.90488
SNOW WATER	2.44	8868.2080
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3587	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

*** 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.

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.65	3.20	4.03	2.75	3.16	3.95
	4.76	5.08	4.02	2.49	2.59	3.86
STD. DEVIATIONS	1.66	1.36	1.92	1.36	1.26	2.48
	2.00	2.45	2.47	1.67	1.94	1.87
RUNOFF						
TOTALS	0.020	0.028	0.054	0.019	0.006	0.065
	0.056	0.079	0.167	0.083	0.041	0.074
STD. DEVIATIONS	0.044	0.076	0.107	0.056	0.024	0.233
	0.143	0.171	0.282	0.166	0.170	0.172
POTENTIAL EVAPOTRANSPIRATION						
TOTALS	2.332	2.517	4.152	5.610	7.169	7.926
	7.863	6.997	5.381	4.069	2.826	2.059
STD. DEVIATIONS	0.215	0.312	0.299	0.318	0.321	0.348
	0.286	0.269	0.301	0.255	0.230	0.177
ACTUAL EVAPOTRANSPIRATION						
TOTALS	1.543	1.683	2.625	2.606	4.301	3.811
	4.496	3.961	2.311	1.401	1.372	1.265
STD. DEVIATIONS	0.257	0.314	0.477	0.544	0.766	1.809
	1.572	1.267	0.788	0.514	0.345	0.255
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7201	1.0317	1.7565	0.6234	0.2767	0.1341
	0.2266	0.3333	0.9260	1.0594	0.7552	1.5894
STD. DEVIATIONS	1.8331	0.8964	1.0737	0.7300	0.5998	0.3559
	0.5828	0.6497	1.1981	1.0676	1.1816	1.2006
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0040	0.0031	0.0042	0.0028	0.0010	0.0004
	0.0007	0.0009	0.0020	0.0030	0.0023	0.0031
STD. DEVIATIONS	0.0017	0.0016	0.0013	0.0015	0.0013	0.0008
	0.0011	0.0013	0.0019	0.0023	0.0017	0.0016
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0040	0.0031	0.0042	0.0028	0.0010	0.0004
	0.0007	0.0009	0.0020	0.0030	0.0023	0.0031
STD. DEVIATIONS	0.0017	0.0016	0.0013	0.0015	0.0013	0.0008
	0.0011	0.0013	0.0019	0.0023	0.0017	0.0016

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0020	0.0013	0.0020	0.0007	0.0003	0.0002
	0.0003	0.0004	0.0013	0.0012	0.0009	0.0018
STD. DEVIATIONS	0.0021	0.0011	0.0012	0.0009	0.0007	0.0004
	0.0007	0.0007	0.0021	0.0012	0.0014	0.0014

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.53 (6.833)	154391.5	100.00
RUNOFF	0.690 (0.4563)	2506.43	1.623
POTENTIAL EVAPOTRANSPIRATION	58.902 (0.8237)	213813.48	
ACTUAL EVAPOTRANSPIRATION	31.376 (3.1983)	113895.23	73.770
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.43247 (3.91878)	37869.863	24.52847
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.02756 (0.00683)	100.059	0.06481
AVERAGE HEAD ON TOP OF LAYER 3	0.001 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	**0.02756 (0.00683)**	**100.059**	**0.06481**
CHANGE IN WATER STORAGE	0.005 (1.1957)	19.88	0.013

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                                                                  **
**              HELP Version 3.95 D          (10 August 2012)       **
**                              developed at                        **
**        Institute of Soil Science, University of Hamburg, Germany **
**                              based on                            **
**              US 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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 TIME:   9.29     DATE:   6.09.2016

 PRECIPITATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d4
 TEMPERATURE DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d7
 SOLAR RADIATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d13
 EVAPOTRANSPIRATION DATA F. 1:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d11
 SOIL AND DESIGN DATA FILE  1:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC1B.d10
 OUTPUT DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC1B.out

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     TITLE:  Davidson County C&DLF - Case 1B (Soil - Side Slopes)

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                          WEATHER DATA SOURCES
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         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA

                    NORMAL MEAN MONTHLY PRECIPITATION (MM)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       89.2        85.6        98.6        80.3        85.6        99.8
      108.5       106.4        92.5        80.8        65.8        85.9

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

                 NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       3.1         4.4         8.9        14.6        19.2        23.1
      25.1        24.6        21.1        14.7         9.2         4.6

         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA
                    AND STATION LATITUDE  =  35.13 DEGREES

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                                LAYER DATA   1
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                              VALID FOR  20 YEARS

       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  10
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2849 VOL/VOL
          EFFECTIVE SAT. HYD. CONDUCT.=      0.1200E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

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                GENERAL DESIGN AND EVAPORATIVE ZONE DATA   1
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                              VALID FOR  20 YEARS

         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  200. FEET.

       SCS RUNOFF CURVE NUMBER             =     76.87
       FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
       EVAPORATIVE ZONE DEPTH              =     21.0    INCHES
       INITIAL WATER IN EVAPORATIVE ZONE   =      5.959  INCHES
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UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.358	INCHES
FIELD CAPACITY OF EVAPORATIVE ZONE	=	5.124	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.856	INCHES
SOIL EVAPORATION ZONE DEPTH	=	21.000	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL INTERCEPTION WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	6.837	INCHES
TOTAL INITIAL WATER	=	6.837	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

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EVAPOTRANSPIRATION DATA 1

VALID FOR 20 YEARS

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GREENSBORO NORTH CAROLINA

STATION LATITUDE	=	35.13	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	90	
END OF GROWING SEASON (JULIAN DATE)	=	305	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	12.23	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.0	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.0	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.0	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.0	%

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	6.4316	0.2680
TOTAL WATER IN LAYERS	6.432	
SNOW WATER	0.000	
INTERCEPTION WATER	0.000	
TOTAL FINAL WATER	6.432	

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	4.09	14834.409
RUNOFF	0.949	3444.4199
PERCOLATION/LEAKAGE THROUGH LAYER 1	2.449526	8891.77832
SNOW WATER	2.44	8868.2080
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3297	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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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	2.65	3.20	4.03	2.75	3.16	3.95
	4.76	5.08	4.02	2.49	2.59	3.86
STD. DEVIATIONS	1.66	1.36	1.92	1.36	1.26	2.48
	2.00	2.45	2.47	1.67	1.94	1.87
RUNOFF						
TOTALS	0.013	0.023	0.046	0.015	0.004	0.053
	0.052	0.073	0.145	0.073	0.036	0.060
STD. DEVIATIONS	0.027	0.064	0.095	0.043	0.016	0.189
	0.139	0.161	0.247	0.144	0.149	0.133
POTENTIAL EVAPOTRANSPIRATION						
TOTALS	2.332	2.517	4.152	5.610	7.169	7.926
	7.863	6.997	5.381	4.069	2.826	2.059
STD. DEVIATIONS	0.215	0.312	0.299	0.318	0.321	0.348
	0.286	0.269	0.301	0.255	0.230	0.177
ACTUAL EVAPOTRANSPIRATION						
TOTALS	1.544	1.683	2.633	2.605	4.230	3.808
	4.490	3.922	2.271	1.394	1.371	1.263

STD. DEVIATIONS	0.259	0.315	0.476	0.544	0.767	1.818
	1.575	1.270	0.812	0.499	0.343	0.260

PERCOLATION/LEAKAGE THROUGH LAYER 1

TOTALS	1.6752	1.0721	1.7758	0.6257	0.2692	0.1718
	0.2374	0.4647	0.9715	1.0511	0.7561	1.6763
STD. DEVIATIONS	1.8098	0.9246	1.1275	0.8044	0.6277	0.4324
	0.5369	0.8966	1.1606	1.1256	1.2289	1.2588

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.53	(6.833)	154391.5	100.00
RUNOFF	0.592	(0.3979)	2148.71	1.392
POTENTIAL EVAPOTRANSPIRATION	58.902	(0.8237)	213813.48	
ACTUAL EVAPOTRANSPIRATION	31.213	(3.2692)	113304.90	73.388
PERCOLATION/LEAKAGE THROUGH LAYER 1	**10.74694**	**(3.96556)**	**39011.395**	**25.26785**
CHANGE IN WATER STORAGE	-0.020	(1.1575)	-73.53	-0.048

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                                                                              **
**              HELP Version 3.95 D          (10 August 2012)                   **
**                                 developed at                                 **
**         Institute of Soil Science, University of Hamburg, Germany            **
**                                  based on                                    **
**              US 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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**********************************************************************************

 TIME:   9.32     DATE:   6.09.2016

 PRECIPITATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d4
 TEMPERATURE DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d7
 SOLAR RADIATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d13
 EVAPOTRANSPIRATION DATA F. 1:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d11
 SOIL AND DESIGN DATA FILE  1:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC2A.d10
 OUTPUT DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC2A.out

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

     TITLE:  Davidson County C&DLF - Case 2A (RMC - Top Slopes)

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                          WEATHER DATA SOURCES
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         NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA

                    NORMAL MEAN MONTHLY PRECIPITATION (MM)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       89.2        85.6        98.6        80.3        85.6        99.8
      108.5       106.4        92.5        80.8        65.8        85.9

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

                    NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       3.1         4.4         8.9        14.6        19.2        23.1
      25.1        24.6        21.1        14.7         9.2         4.6

         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA
                    AND STATION LATITUDE  =  35.13 DEGREES

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                                LAYER DATA   1
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                              VALID FOR  20 YEARS

       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  10
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2773 VOL/VOL
          EFFECTIVE SAT. HYD. CONDUCT.=      0.1200E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER  15
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4750 VOL/VOL
          FIELD CAPACITY               =      0.3780 VOL/VOL
          WILTING POINT                =      0.2650 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.4750 VOL/VOL
          EFFECTIVE SAT. HYD. CONDUCT.=      0.1000E-04 CM/SEC
```

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3980 VOL/VOL
FIELD CAPACITY	=	0.2440 VOL/VOL
WILTING POINT	=	0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2872 VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1200E-03 CM/SEC

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GENERAL DESIGN AND EVAPORATIVE ZONE DATA 1

VALID FOR 20 YEARS

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 100. FEET.

SCS RUNOFF CURVE NUMBER	=	76.72	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.991	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.164	INCHES
FIELD CAPACITY OF EVAPORATIVE ZONE	=	4.392	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.448	INCHES
SOIL EVAPORATION ZONE DEPTH	=	18.000	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL INTERCEPTION WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	16.988	INCHES
TOTAL INITIAL WATER	=	16.988	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

****

EVAPOTRANSPIRATION DATA 1

VALID FOR 20 YEARS

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM GREENSBORO NORTH CAROLINA

STATION LATITUDE	=	35.13 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	90
END OF GROWING SEASON (JULIAN DATE)	=	305
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	12.23 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.0 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.0 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.0 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.0 %

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	5.0534	0.2807
2	8.5500	0.4750
3	4.0453	0.3371
TOTAL WATER IN LAYERS	17.649	
SNOW WATER	0.000	
INTERCEPTION WATER	0.000	
TOTAL FINAL WATER	17.649	

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	4.09	14834.409
RUNOFF	0.921	3342.5291
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.645848	2344.42847
AVERAGE HEAD ON TOP OF LAYER 2	16.176	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.632554	2296.17114
SNOW WATER	2.44	8868.2080
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.65	3.20	4.03	2.75	3.16	3.95
	4.76	5.08	4.02	2.49	2.59	3.86
STD. DEVIATIONS	1.66	1.36	1.92	1.36	1.26	2.48
	2.00	2.45	2.47	1.67	1.94	1.87
RUNOFF						
TOTALS	0.012	0.023	0.042	0.012	0.004	0.058
	0.050	0.072	0.145	0.068	0.033	0.071
STD. DEVIATIONS	0.026	0.062	0.087	0.036	0.015	0.203
	0.132	0.158	0.249	0.133	0.137	0.179
POTENTIAL EVAPOTRANSPIRATION						
TOTALS	2.332	2.517	4.152	5.610	7.169	7.926
	7.863	6.997	5.381	4.069	2.826	2.059
STD. DEVIATIONS	0.215	0.312	0.299	0.318	0.321	0.348
	0.286	0.269	0.301	0.255	0.230	0.177
ACTUAL EVAPOTRANSPIRATION						
TOTALS	1.540	1.680	2.635	2.609	3.906	3.755
	4.397	3.875	2.279	1.471	1.362	1.256
STD. DEVIATIONS	0.251	0.313	0.475	0.540	0.845	1.824
	1.563	1.288	0.854	0.529	0.347	0.273
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	1.5959	1.1538	1.7091	0.5136	0.2421	0.2716
	0.3258	0.5157	1.1865	1.0576	0.7705	1.8314
STD. DEVIATIONS	1.8255	0.9478	1.2036	0.8775	0.6876	0.5845
	0.6333	0.9309	1.3432	1.1257	1.3736	1.2574
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	1.7713	1.0271	1.7941	0.7417	0.3230	0.2307
	0.3303	0.4530	1.0786	1.0947	0.7840	1.5151
STD. DEVIATIONS	1.8627	0.8577	1.0719	0.7146	0.6178	0.4608
	0.5593	0.7576	1.3049	1.0549	1.1708	1.1274

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.2486	0.1912	0.2831	0.1026	0.0423	0.0600
	0.0639	0.0991	0.3128	0.2061	0.1462	0.3581
STD. DEVIATIONS	0.4596	0.3246	0.3276	0.2593	0.1485	0.2051
	0.1846	0.2178	0.4298	0.3678	0.4681	0.4542

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.53	(6.833)	154391.5	100.00
RUNOFF	0.588	(0.4134)	2135.71	1.383
POTENTIAL EVAPOTRANSPIRATION	58.902	(0.8237)	213813.48	
ACTUAL EVAPOTRANSPIRATION	30.767	(3.1921)	111684.23	72.338
PERCOLATION/LEAKAGE THROUGH LAYER 2	11.17362	(3.97219)	40560.234	26.27104
AVERAGE HEAD ON TOP OF LAYER 2	0.176	(0.093)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	**11.14369**	**(3.90051)**	**40451.598**	**26.20067**
CHANGE IN WATER STORAGE	0.033	(1.2532)	119.93	0.078

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 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                                                                          **
 **              HELP Version 3.95 D          (10 August 2012)              **
 **                                developed at                              **
 **        Institute of Soil Science, University of Hamburg, Germany         **
 **                                  based on                                **
 **              US HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)               **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
 **                    USAE WATERWAYS EXPERIMENT STATION                     **
 **              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************

 TIME:   9.33     DATE:   6.09.2016

 PRECIPITATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d4
 TEMPERATURE DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d7
 SOLAR RADIATION DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d13
 EVAPOTRANSPIRATION DATA F. 1:
C:\Users\PieterScheer\Documents\HELPMod\HELP390D\Projects\GreensboroNC.d11
 SOIL AND DESIGN DATA FILE  1:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC2B.d10
 OUTPUT DATA FILE:
C:\Users\PieterScheer\Documents\HELPMod\HELP395D\Projects\DCLFC2B.out

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

     TITLE:  Davidson County C&DLF - Case 2B (RMC - Side Slopes)

 ******************************************************************************
                           WEATHER DATA SOURCES
 ------------------------------------------------------------------------------

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

                    NORMAL MEAN MONTHLY PRECIPITATION (MM)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       89.2        85.6        98.6        80.3        85.6        99.8
      108.5       106.4        92.5        80.8        65.8        85.9
```

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

                NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       3.1         4.4         8.9        14.6        19.2        23.1
      25.1        24.6        21.1        14.7         9.2         4.6

         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    GREENSBORO          NORTH CAROLINA
                    AND STATION LATITUDE  =  35.13 DEGREES

 ******************************************************************************
                                 LAYER DATA   1
 ------------------------------------------------------------------------------

                              VALID FOR  20 YEARS

      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  10
        THICKNESS                    =     18.00   INCHES
        POROSITY                     =      0.3980 VOL/VOL
        FIELD CAPACITY               =      0.2440 VOL/VOL
        WILTING POINT                =      0.1360 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2773 VOL/VOL
        EFFECTIVE SAT. HYD. CONDUCT.=      0.1200E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

                                   LAYER  2
                                   --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  15
        THICKNESS                    =     18.00   INCHES
        POROSITY                     =      0.4750 VOL/VOL
        FIELD CAPACITY               =      0.3780 VOL/VOL
        WILTING POINT                =      0.2650 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.4750 VOL/VOL
        EFFECTIVE SAT. HYD. CONDUCT.=      0.1000E-04 CM/SEC
```

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	= 12.00	INCHES
POROSITY	= 0.3980	VOL/VOL
FIELD CAPACITY	= 0.2440	VOL/VOL
WILTING POINT	= 0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	= 0.2872	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	= 0.1200E-03	CM/SEC

****

GENERAL DESIGN AND EVAPORATIVE ZONE DATA 1

VALID FOR 20 YEARS

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 200. FEET.

SCS RUNOFF CURVE NUMBER	= 76.87	
FRACTION OF AREA ALLOWING RUNOFF	= 100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	= 1.000	ACRES
EVAPORATIVE ZONE DEPTH	= 18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	= 4.991	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	= 7.164	INCHES
FIELD CAPACITY OF EVAPORATIVE ZONE	= 4.392	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	= 2.448	INCHES
SOIL EVAPORATION ZONE DEPTH	= 18.000	INCHES
INITIAL SNOW WATER	= 0.000	INCHES
INITIAL INTERCEPTION WATER	= 0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	= 16.988	INCHES
TOTAL INITIAL WATER	= 16.988	INCHES
TOTAL SUBSURFACE INFLOW	= 0.00	INCHES/YEAR

****

EVAPOTRANSPIRATION DATA 1

VALID FOR 20 YEARS

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM GREENSBORO NORTH CAROLINA

STATION LATITUDE	= 35.13	DEGREES
MAXIMUM LEAF AREA INDEX	= 2.00	
START OF GROWING SEASON (JULIAN DATE)	= 90	
END OF GROWING SEASON (JULIAN DATE)	= 305	
EVAPORATIVE ZONE DEPTH	= 18.0	INCHES
AVERAGE ANNUAL WIND SPEED	= 12.23	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	= 66.0	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	= 68.0	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	= 74.0	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	= 70.0	%

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	5.0516	0.2806
2	8.5500	0.4750
3	4.0453	0.3371
TOTAL WATER IN LAYERS	17.647	
SNOW WATER	0.000	
INTERCEPTION WATER	0.000	
TOTAL FINAL WATER	17.647	

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	4.09	14834.409
RUNOFF	0.932	3383.2461
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.645848	2344.42822
AVERAGE HEAD ON TOP OF LAYER 2	16.176	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.632333	2295.36743
SNOW WATER	2.44	8868.2080
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.65	3.20	4.03	2.75	3.16	3.95
	4.76	5.08	4.02	2.49	2.59	3.86
STD. DEVIATIONS	1.66	1.36	1.92	1.36	1.26	2.48
	2.00	2.45	2.47	1.67	1.94	1.87
RUNOFF						
TOTALS	0.012	0.023	0.043	0.013	0.004	0.059
	0.052	0.073	0.148	0.069	0.034	0.072
STD. DEVIATIONS	0.027	0.063	0.088	0.038	0.016	0.206
	0.135	0.161	0.253	0.135	0.139	0.179
POTENTIAL EVAPOTRANSPIRATION						
TOTALS	2.332	2.517	4.152	5.610	7.169	7.926
	7.863	6.997	5.381	4.069	2.826	2.059
STD. DEVIATIONS	0.215	0.312	0.299	0.318	0.321	0.348
	0.286	0.269	0.301	0.255	0.230	0.177
ACTUAL EVAPOTRANSPIRATION						
TOTALS	1.540	1.680	2.635	2.609	3.906	3.755
	4.397	3.875	2.278	1.471	1.362	1.256
STD. DEVIATIONS	0.251	0.313	0.475	0.540	0.845	1.824
	1.564	1.288	0.854	0.529	0.347	0.273
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	1.5952	1.1535	1.7081	0.5132	0.2418	0.2706
	0.3247	0.5145	1.1839	1.0562	0.7699	1.8310
STD. DEVIATIONS	1.8246	0.9471	1.2024	0.8764	0.6866	0.5822
	0.6310	0.9290	1.3396	1.1238	1.3716	1.2570
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	1.7707	1.0265	1.7931	0.7413	0.3227	0.2302
	0.3283	0.4525	1.0761	1.0931	0.7833	1.5149
STD. DEVIATIONS	1.8633	0.8572	1.0708	0.7137	0.6168	0.4595
	0.5555	0.7570	1.3018	1.0531	1.1685	1.1273

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.2483	0.1908	0.2831	0.1024	0.0421	0.0595
	0.0635	0.0982	0.3107	0.2046	0.1455	0.3580
STD. DEVIATIONS	0.4588	0.3237	0.3281	0.2584	0.1480	0.2033
	0.1832	0.2160	0.4252	0.3663	0.4654	0.4542

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.53	(6.833)	154391.5	100.00
RUNOFF	0.602	(0.4199)	2183.46	1.414
POTENTIAL EVAPOTRANSPIRATION	58.902	(0.8237)	213813.48	
ACTUAL EVAPOTRANSPIRATION	30.765	(3.1931)	111676.82	72.334
PERCOLATION/LEAKAGE THROUGH LAYER 2	11.16259	(3.96653)	40520.207	26.24511
AVERAGE HEAD ON TOP OF LAYER 2	0.176	(0.093)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	**11.13267**	**(3.89574)**	**40411.574**	**26.17475**
CHANGE IN WATER STORAGE	0.033	(1.2549)	119.60	0.077

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TEL: 919.828.0577
WEB: www.smithgardnerinc.com

PROJECT Davidson County C&DLF | SHEET 1 OF 2 | DATE 9/20/2016
COMPUTED BY PKS
SUBJECT Final Cover Drainage Layer Analysis | JOB # DAVDCO-16-12 | CHECKED BY GGM

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

REFERENCE: Richardson, G.N., Giroud, J-P., and Zhao, A. (2000), Design 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:

$$\theta_{reqd} = \frac{RF_{dc} q_n Li}{\sin\beta} = \frac{RF_{dc} q_n L \cos\beta}{\sin\beta} = \frac{RF_{dc} q_n L}{\tan\beta}$$ (Richardson et. al. Eq. 4-6 Mod.)

where:

θ_{reqd}	=	required transmissivity ($m^3/m/sec$)
RF_{dc}	=	drainage geocomposite reduction factor (See Note 1)
q_n	=	fluid input rate (or impingement rate) (m/s) (See Note 2)
L	=	flow length (or drain spacing) (horizontally projected) (m)
β	=	slope angle of final cover (degrees)

Notes:

1. Based on the recommendations of Richardson, Giroud, & Zhao, use RF_{dc} = 6. This accounts for an overall factor of safety of 2, plus a combined reduction factor of 3 for long-term intrusion, creep, and clogging concerns. A lower reduction factor may be used where veneer stability is not a significant concern.
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 (approximately equal to slope of cover system for most slopes).

Step 3:

Calculate the required total flow capactiy (Q) of the drain basin on the following equation:

$$Q = q_n A$$

where:

Q	=	flow capacity (cfs)
q_n	=	impingement (ft/s)
A	=	total area served by the drain (= L x DL) (ft^2)
DL	=	length of drain between outlet locations (ft).

Step 4:

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

PROJECT	**Davidson County C&DLF**	SHEET	2/2
		JOB #	DAVDCO-15-12
SUBJECT	**Final Cover Drainage Layer Analysis**	DATE	9/20/2016
		COMPUTED BY	PKS
		CHECKED BY	GGM

Input Parameters:

Side Slope Angle (β):	4.8	degrees	(12.0H:1V Slope)	***8% Slope***
Impingement (q_n):	0.0001	cm/sec	(= Permeability of Vegetative Soil Layer)	
Drain Spacing (L):	100	ft	(= Horizontally Projected Distance Up & Down Slope) (> Max.)	

Reduction Factors for Drainage Geocomposite: (Based on Limited Concern with Veneer Stability)

$RF_{intrusion}$:	1.1	
RF_{creep}:	1.1	
$RF_{chemical\ clogging}$:	1.1	
$RF_{biological\ clogging}$:	1.1	
Overall Factor of Safety (FS):	1.9	
Reduction Factor for Drainage Geocomposite in Final Cover (RF_{dc}):	2.8	
Drain Length (DL):	225 ft	(> Max. Flow Length to Down Pipes)

Final Cover:	Thickness:	2.0	ft
	Unit Weight:	110	pcf

Note: Spreadsheet Converts Units as Required.

Transmissivity Requirements:

Determine Minimum Transmissivity:

θ_{min} = 1.0E-03 $m^3/m/sec$ = 4.9 gpm/ft

Determine Transmissivity Test Parameters:

Min. Normal Stress = 220.0 psf

Hydraulic Gradient = 0.08

Determine Required Drain Capacity:

Calculate Required Total Flow Capacity:

Q = 0.07 cfs *Based on 225 foot spacing between outlets.

6" CPE (Type SP) pipe embedded in No. 57 stone will have more than sufficient flow capacity.

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PROJECT Davidson County C&D Landfill SHEET 1 OF 12 DATE 9/20/2016

COMPUTED BY PKS

SUBJECT Filter Geotextile Analysis JOB # DAVDCO-16-12 CHECKED BY GGM

OBJECTIVE:

To determine the maximum geotextile apparent opening size (AOS) to provide proper retention to protect drainage media from piping and clogging from adjacent soil. Additionally, to determine the minimum required geotextile permittivity to provide proper drainage from the adjacent soil. Geotextile filtration properties must be selected based on the up-gradient soil gradation and plasticity and site specific hydraulic conditions.

REFERENCES:

Bhatia, S.K. and Huang, Q. (1995), "Geotextile Filters for Internally Stable/Unstable Soils", Geosynthetics International, Vol. 2, No. 3, pp. 537-565.

Koerner, Robert M. (1999), Designing with Geosynthetics, 4th Ed., Prentice-Hall Inc., Englewood Cliffs, NJ, pp. 84-91.

Mirafi - Geotextile Filter Design, Application, and Product Selection Guide, Ten Cate Nicolon Corp. (www.mirafi.com).

Richardson, G.N., Giroud, J-P., and Zhao, A. (2000), Design of Lateral Drainage Systems for Landfills, Tenax Corp., Baltimore.

ASSUMPTIONS:

The design criteria given assume that the soil is "set" in intimate contact with the geotextile.

BACKGROUND:

From Richardson et. al.:

For the purposes of filtration design, soils can be characterized as stable or unstable. Stable soils perform an internal filtration process that limits migration of fines within the soil. Typically, these soil types include well-graded soils. Unstable soils are those which cannot perform self-filtration (i.e. they have the potential to pipe internally). They may include gap-graded, broad-graded, and other highly erodible soils. In gap-graded soils, there exists a coarse and fine fraction, but very little medium fraction. If there is an insufficient quantity of soil particles in the medium fraction, fine soil particles pipe through the coarse fraction. In broad-graded soils, the gradation is distributed over a very wide range of particle sizes such that fine soil tends to pipe through coarser particles.

ANALYSIS:

1. Define Application and Function of Geotextile:

Define the application and function of the geotextile (i.e. where the geotextile is to be used and whether retention or permeability is the key function of the material) and also the confining stress (i.e. high - leachate collection system; low - final cover system) and flow conditions (i.e. steady-state - landfill drains; dynamic - shoreline protection).

2. Evaluate Soils Information

For representative soils, evaluate grain size and plasticity information. From the grain size curves determine the coefficients of uniformity and curvature as follows:

$$C_u = \frac{d_{60}}{d_{10}} \qquad C_c = \frac{d_{30}^{\,2}}{(d_{10} \times d_{60})}$$

where: C_u = coefficient of uniformity (quantifies the distribution of particle sizes)
C_c = coefficient of curvature (identifies internal soil stability)
d_x = the diameter at which x percent of the soil is finer

For $C_u \leq 4$, the soil is uniformly-graded; for $4 < C_u \leq 20$, the soil is well-graded; and for $C_u > 20$, the soil is broad-graded. Uniformly-graded and broad-graded soils require careful analysis. Gap-graded soils which have a coarse and fine fraction, but limited medium fraction are of particular concern and should be avoided. Gap-graded soils are readily identified by the appearance of the grain size curve. For $1 \leq C_c \leq 3$, the soil should be internally stable (Bhatia and Huang state that soils having $C_c \leq 7$ are internally stable.).

Additionally, in general, particles do not move within soils having a plasticity index (PI) greater than 15% so there is no clogging potential (Richardson et. al.).

3. Selection of Soil Retention Requirements (Maximum AOS):

To determine the maximum AOS, use the method given in Koerner/Mirafi (after Luettich) and the method given in Bhatia and Huang. For the AOS determined by either method, the following shows the relationship between opening size and the corresponding U.S. sieve number (with typical non-woven geotextile information as shown).

Opening Size (mm)	U.S. Sieve	
0.150	100	(most 10 to 16 oz/SY non-woven geotextiles)
0.180	80	(most 8 oz/SY non-woven geotextiles)
0.212	70	(most 4 to 6 oz/SY non-woven geotextiles)
0.250	60	
0.300	50	
0.425	40	
0.600	30	

- Luettich Method:

For steady-state conditions, use the chart below.

- Bhatia and Huang Method:

Bhatia and Huang developed the following retention criteria:

For $n \geq 60\%$ $\quad O_{95} < d_{85}(2.71 - 0.36C_c)$ $\quad C_c \leq 7$

For $n < 60\%$ $\quad O_{95} < d_{85}(0.65 - 0.05C_c)$ $\quad C_c > 7$

where: O_{95} = apparent opening size
n = geotextile porosity (%) (for non-woven geotextiles this value is typically 70 to 90%)

4. Determine Geotextile Permittivity Requirements:

Determine the geotextile permittivity requirements:

$$\Psi = \frac{k_g}{t_g} \qquad (\text{sec}^{-1})$$

where: ψ = mimimum required geotextile permittivity (sec^{-1})
k_g = mimimum allowable geotextile permeability (cm/sec)
$k_g \geq i_s k_s$
t_g = geotextile thickness under design load (cm)
i_s = hydraulic gradient (use 1.5 for landfills)
k_s = permeability of retained soil (cm/sec)

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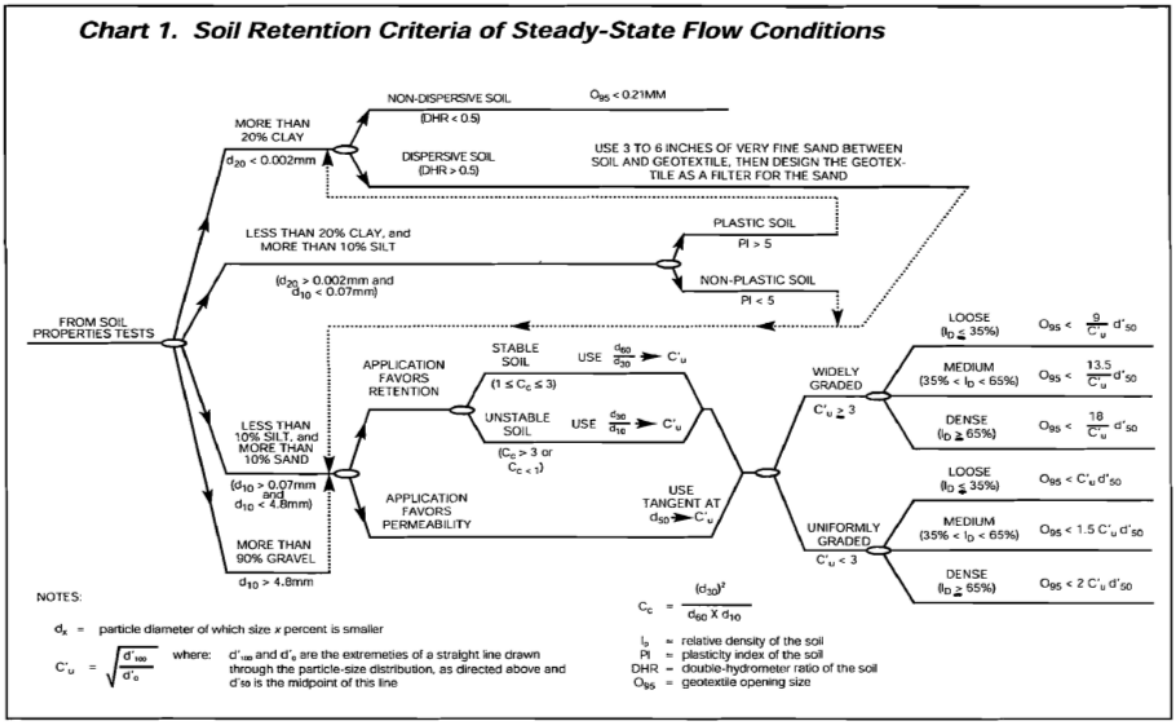
5. Other Considerations

Other things to consider in the design of a filter geotextile include anti-clogging requirements and survivability/durability requirements. For anti-clogging, it is generally best to use the largest AOS that satisfies the retention criteria. For non-woven geotextiles used in landfill applications, an AOS of 0.21 mm (No. 70 sieve) is typically the largest AOS that is available. For survivability/durability concerns, generally an adequately UV stabilized geotextile made from polypropylene or polyester with an AASHTO M288 Strength Class of 2 is suitable for use in subsurface drainage applications.

Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



Ref: Mirafi (After Luettich)

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PROJECT Davidson County C&D Landfill

SUBJECT Filter Geotextile Analysis (Final Cover System)

SHEET	4/12
JOB #	DAVDCO-16-12
DATE	9/20/2016
COMPUTED BY	PKS
CHECKED BY	GGM

Application:	Final Cover System Drainage Geocomposite
Primary Function:	Retention/Permeability
Relative Confining Stress:	Low
Flow Conditions:	Steady-State

	Typ. SC (Sample 01-01)	Typ. SM (Sample 04-01)	**Soil Evaluated**
Soil Description:	Brown Clayey Sand	Reddish Brown Silty Sand	
Soil Type:	SC	SM	
Particle Size (mm) d_{85}:	3.400	2.500	
Particle Size (mm) d_{60}:	0.700	0.210	
Particle Size (mm) d_{50}:	0.250	0.090	
Particle Size (mm) d_{30}:	0.030	0.021	
Particle Size (mm) d_{20}:	0.010	0.010	
Particle Size (mm) d_{10}:	0.003	0.005	
PI:	13	8	
C_u:	233.33	42.00	
	Use Caution - Soil is Broad Graded!	Use Caution - Soil is Broad Graded!	
C_c:	0.43	0.42	
Luettich Method:*	-----	-----	
Soil Dispersion (When Applicable):	Is Soil Dispersive? (Y/N)	Is Soil Dispersive? (Y/N)	
	N	N	
Recommended Maximum AOS (mm) (When Applicable):	**0.210**	**0.210**	
	No. 70 Sieve	**No. 70 Sieve**	
Internal Soil Stability (When Applicable):	NA	NA	
Particle Size (mm) for Determining C'_u d'_{100}:			
Particle Size (mm) for Determining C'_u d'_{50}:			
Particle Size (mm) for Determining C'_u d'_0:			
C'_u (When Applicable):			
Soil Relative Density (I_D) (Loose (L), Medium (M), Dense (D) (When Applicable):			
Recommended Maximum AOS (mm) (When Applicable):			
Bhatia & Huang Method:	-----	-----	
Internal Soil Stability:	Soil is Stable.	Soil is Stable.	
Geotextile Porosity (%):	80	80	
Recommended Max. AOS (mm):	**8.689**	**6.397**	
	No. 30 Sieve	**No. 30 Sieve**	
Required Geotextile Properties:	-----	-----	
Hydraulic Gradient (i_s):	1.5	1.5	
Estimated Soil Permeability (k_s) (cm/sec):	1.0E-04	1.0E-04	
Min. Allowable Geotextile Permeability (k_g) (cm/sec):	1.5E-04	1.5E-04	
Geotextile Thickness (t_g) (cm):	0.25	0.25	
Min. Required Geotextile Permittivity (Ψ) (sec^{-1}):	**0.0006**	**0.0006**	

***Note: Spreadsheet assumes retention application in using the Luettich Method.**

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ATTERBERG LIMITS

ASTM D 4318-10 / AASHTO T89-10 (SOP - S4A)

Client	R.S.G. & ASSOCIATES	Boring No.	NA
Client Reference	DAVIDSON CO. LF C & D	Depth (ft)	NA
Project No.	2012-686-01	Sample No.	1
Lab ID	2012-686-01-01	Soil Description	**BROWN LEAN CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

(Minus No. 40 sieve material, Airdried)

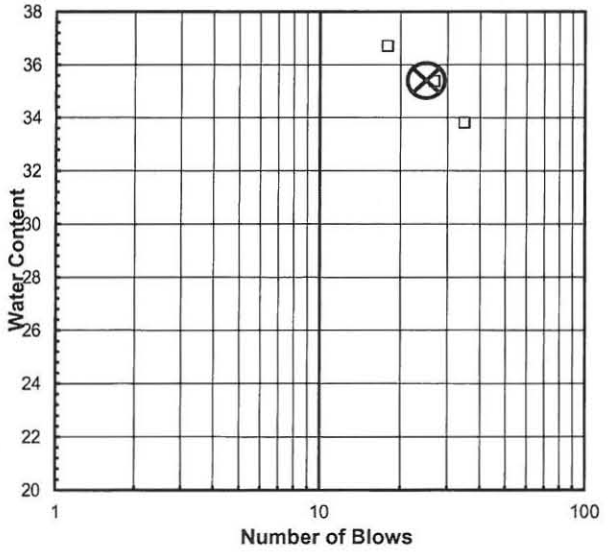
Liquid Limit Test	**1**	**2**	**3**	MULTIPOINT
Tare Number	A-O	17	Z-4	
Wt. of Tare & WS (gm)	32.88	33.41	31.52	
Wt. of Tare & DS (gm)	28.47	28.72	27.24	
Wt. of Tare (gm)	15.42	15.46	15.57	
Wt. of Water (gm)	4.4	4.7	4.3	
Wt. of DS (gm)	13.1	13.3	11.7	
Moisture Content (%)	**33.8**	**35.4**	**36.7**	
Number of Blows	**35**	**27**	**18**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	W-5	V-2	
Wt. of Tare & WS (gm)	23.16	22.81	
Wt. of Tare & DS (gm)	21.79	21.54	
Wt. of Tare (gm)	15.61	15.60	
Wt. of Water (gm)	1.4	1.3	
Wt. of DS (gm)	6.2	5.9	
Moisture Content (%)	**22.2**	**21.4**	**0.8**

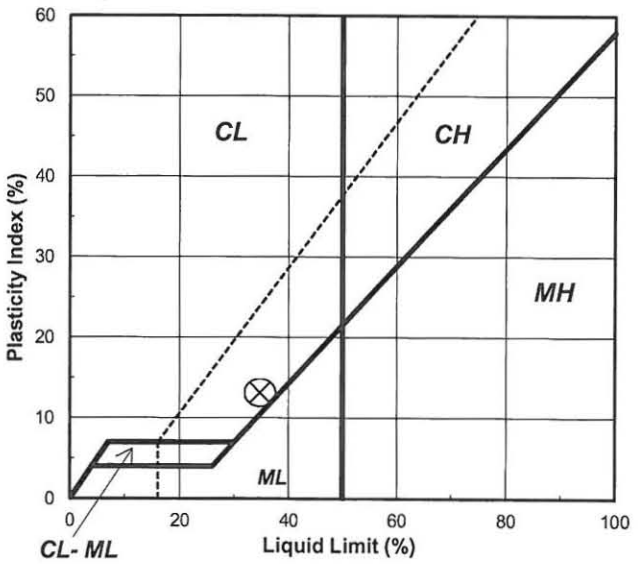
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**35**
Plastic Limit (%)	**22**
Plasticity Index (%)	**13**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By CG *Date* 6/20/2012 *Checked By* Gam *Date* 6-21-12

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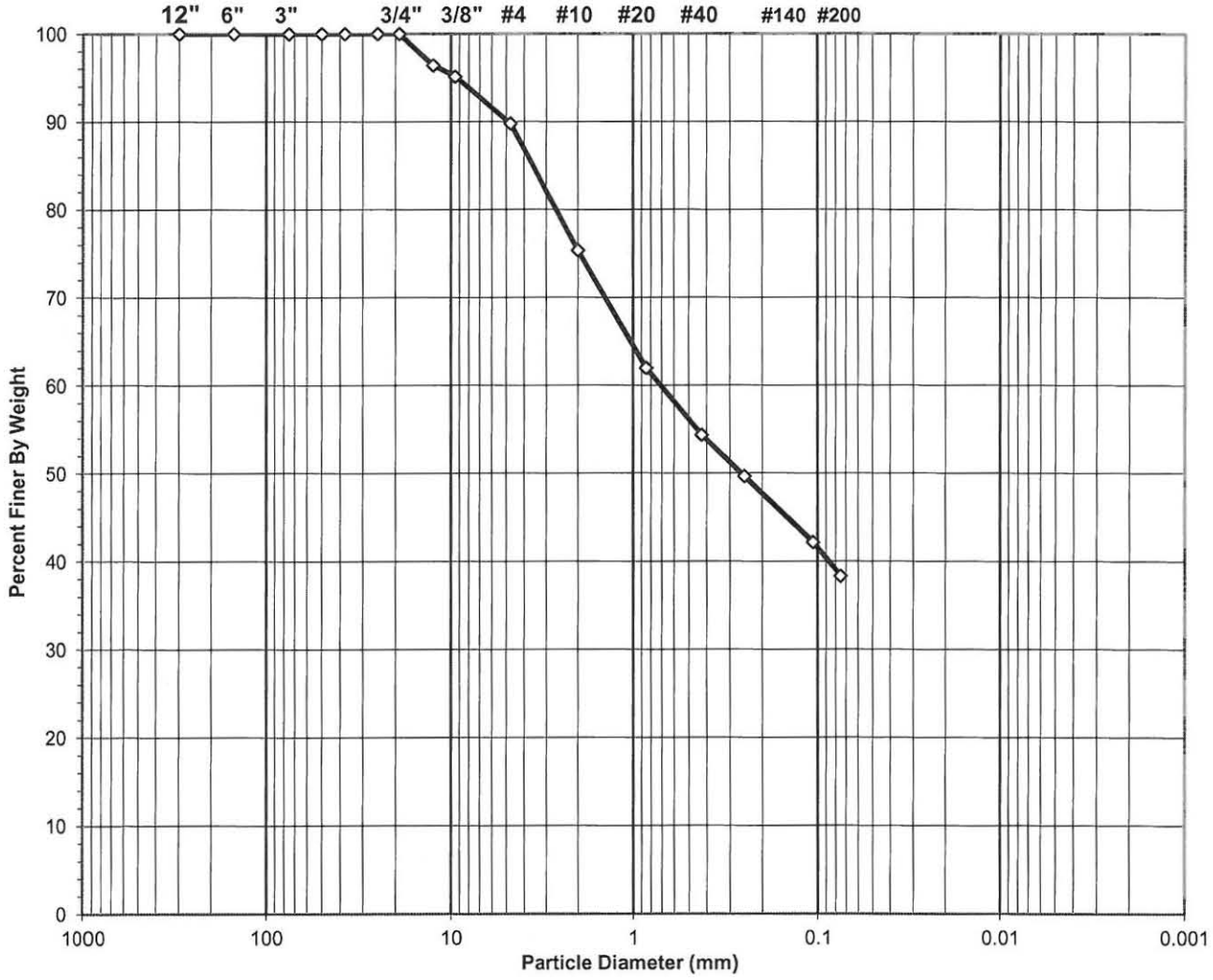
SIEVE ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	R.S.G. & ASSOCIATES	Boring No.	NA
Client Reference	DAVIDSON CO. LF C & D	Depth (ft)	NA
Project No.	2012-686-01	Sample No.	1
Lab ID	2012-686-01-01	Soil Color	**BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol ***SC, TESTED***

USCS Classification CLAYEY SAND

Tested By JBD Date 6/20/2012 Checked By GEM Date 6-21-12

DCN: CT-S3C DATE 6-25-98 REVISION:Z2\2012 PROJECTS\2012-686 RSG -DAVIDSON CO\[2012-686-01-01 SIEVON REV 4 wHeader.xls]Sheet1

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WASH SIEVE ANALYSIS

ASTM D 422-63 (SOP-S3)

Client	R.S.G. & ASSOCIATES	Boring No.	NA
Client Reference	DAVIDSON CO. LF C & D	Depth (ft)	NA
Project No.	2012-686-01	Sample No.	1
Lab ID	2012-686-01-01	Soil Color	**BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	200	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	791.11	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	721.84	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	171.61	Weight of Tare (gm)	NA
Weight of Water (gm)	69.27	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	550.23	Weight of Dry Soil (gm)	NA
Moisture Content (%)	**12.6**	**Moisture Content (%)**	**NA**

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	550.23
Dry Weight - 3/4" Sample (gm)	339.3	Weight of minus #200 material (gm)	210.98
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	339.25
Dry Weight + 3/4" Sample (gm)	0.00		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.0	0.0	100.0	**100.0**
6"	150	0.00	0.0	0.0	100.0	**100.0**
3"	75	0.00	0.0	0.0	100.0	**100.0**
2"	50	0.00	0.0	0.0	100.0	**100.0**
1 1/2"	37.5	0.00	0.0	0.0	100.0	**100.0**
1"	25.0	0.00	0.0	0.0	100.0	**100.0**
3/4"	19.0	0.00	0.0	0.0	100.0	**100.0**
1/2"	12.50	19.64	3.6	3.6	96.4	**96.4**
3/8"	9.50	7.00	1.3	4.8	95.2	**95.2**
#4	4.75	29.50	5.4	10.2	89.8	**89.8**
#10	2.00	79.26	14.4	24.6	75.4	**75.4**
#20	0.850	73.62	13.4	38.0	62.0	**62.0**
#40	0.425	42.04	7.6	45.6	54.4	**54.4**
#60	0.250	25.83	4.7	50.3	49.7	**49.7**
#140	0.106	41.31	7.5	57.8	42.2	**42.2**
#200	0.075	21.05	3.8	61.7	38.3	**38.3**
Pan	-	210.98	38.3	100.0	-	-

Tested By JBD Date 6/20/2012 Checked By GAM Date 6-21-12

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ATTERBERG LIMITS

ASTM D 4318-10

Client	RSG & ASSOCIATES	Boring No.	NA
Client Reference	DAVIDSON CO. LF C & D	Depth (ft)	NA
Project No.	2012-686-04	Sample No.	MSW BORROW
Lab ID	2012-686-04-01	Soil Description	**REDDISH BROWN SILT**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

(Minus No. 40 sieve material, Airdried)

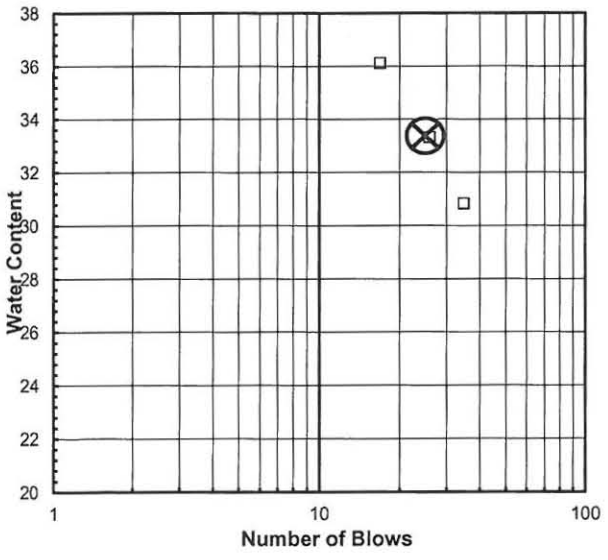
Liquid Limit Test	**1**	**2**	**3**	
				M
Tare Number	A-O	W-5	Z-4	**U**
Wt. of Tare & WS (gm)	30.38	30.21	31.94	**L**
Wt. of Tare & DS (gm)	26.85	26.56	27.60	**T**
Wt. of Tare (gm)	15.39	15.60	15.58	**I**
Wt. of Water (gm)	3.5	3.7	4.3	**P**
Wt. of DS (gm)	11.5	11.0	12.0	**O**
				I
Moisture Content (%)	**30.8**	**33.3**	**36.1**	**N**
Number of Blows	**35**	**26**	**17**	**T**

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	17	V-2	
Wt. of Tare & WS (gm)	22.78	22.25	
Wt. of Tare & DS (gm)	21.30	20.89	
Wt. of Tare (gm)	15.47	15.58	
Wt. of Water (gm)	1.5	1.4	
Wt. of DS (gm)	5.8	5.3	
Moisture Content (%)	**25.4**	**25.6**	**-0.2**

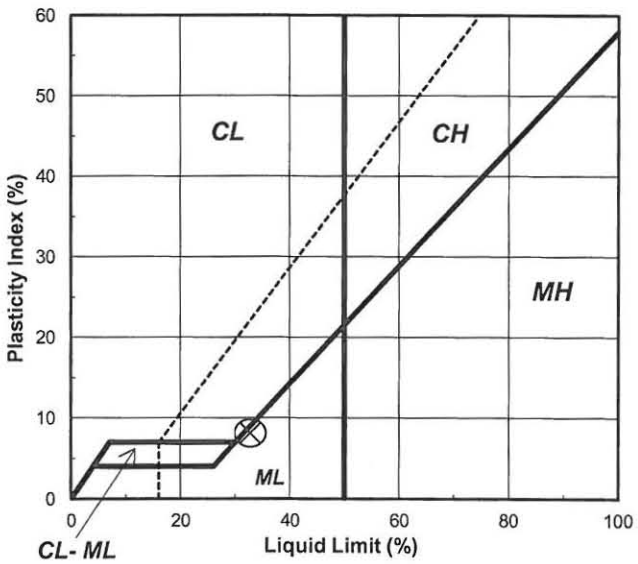
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**33**
Plastic Limit (%)	**25**
Plasticity Index (%)	**8**
USCS Symbol	**ML**

Flow Curve



Plasticity Chart



Tested By JBD *Date* 7/6/2012 *Checked By* GDM *Date* 7-9-12

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SIEVE ANALYSIS
ASTM D 422-63 (2007)

Client	RSG & ASSOCIATES	Boring No.	NA
Client Reference	DAVIDSON CO. LF C & D	Depth (ft)	NA
Project No.	2012-686-04	Sample No.	MSW BORROW
Lab ID	2012-686-04-01	Soil Color	**REDDISH BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	**gravel**	**sand**	**silt and clay**

USCS Symbol ***SM, TESTED***

USCS Classification SILTY SAND

Tested By SFS Date 7/3/2012 Checked By GEM Date 7-9-12

DCN: CT-S3C DATE 6-25-98 REVISION:Z2\2012 PROJECTS\2012-686 RSG -DAVIDSON CO\[2012-686-04-01 SIEVON REV 4 wHeader.xls]Sheet1

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client	RSG & ASSOCIATES	Boring No.	NA
Client Reference	DAVIDSON CO. LF C & D	Depth (ft)	NA
Project No.	2012-686-04	Sample No.	MSW BORROW
Lab ID	2012-686-04-01	Soil Color	**REDDISH BROWN**

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	835	Tare No.	NA
Wgt.Tare + Wet Specimen (gm)	997.76	Wgt.Tare + Wet Specimen (gm)	NA
Wgt.Tare + Dry Specimen (gm)	922.09	Wgt.Tare + Dry Specimen (gm)	NA
Weight of Tare (gm)	254.98	Weight of Tare (gm)	NA
Weight of Water (gm)	75.67	Weight of Water (gm)	NA
Weight of Dry Soil (gm)	667.11	Weight of Dry Soil (gm)	NA
Moisture Content (%)	**11.3**	**Moisture Content (%)**	**NA**

Wet Weight -3/4" Sample (gm)	NA	Weight of the Dry Specimen (gm)	667.11
Dry Weight - 3/4" Sample (gm)	355.9	Weight of minus #200 material (gm)	311.22
Wet Weight +3/4" Sample (gm)	NA	Weight of plus #200 material (gm)	355.89
Dry Weight + 3/4" Sample (gm)	0.00		
Total Dry Weight Sample (gm)	NA		

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.0	0.0	100.0	**100.0**
6"	150	0.00	0.0	0.0	100.0	**100.0**
3"	75	0.00	0.0	0.0	100.0	**100.0**
2"	50	0.00	0.0	0.0	100.0	**100.0**
1 1/2"	37.5	0.00	0.0	0.0	100.0	**100.0**
1"	25.0	0.00	0.0	0.0	100.0	**100.0**
3/4"	19.0	0.00	0.0	0.0	100.0	**100.0**
1/2"	12.50	49.72	7.5	7.5	92.5	**92.5**
3/8"	9.50	6.34	1.0	8.4	91.6	**91.6**
#4	4.75	19.05	2.9	11.3	88.7	**88.7**
#10	2.00	37.80	5.7	16.9	83.1	**83.1**
#20	0.850	58.37	8.7	25.7	74.3	**74.3**
#40	0.425	44.89	6.7	32.4	67.6	**67.6**
#60	0.250	36.70	5.5	37.9	62.1	**62.1**
#140	0.106	65.59	9.8	47.7	52.3	**52.3**
#200	0.075	37.43	5.6	53.3	46.7	**46.7**
Pan	-	311.22	46.7	100.0	-	-

Tested By SFS Date 7/3/2012 Checked By GEM Date 7-9-12

DCN: CT-S3C DATE 6-25-98 REVISION:Z2\2012 PROJECTS\2012-686 RSG -DAVIDSON CO\[2012-686-04-01 SIEVON REV 4 wHeader.xls]Sheet1

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PROJECT Davidson County - C&DLF | SHEET 1 OF 2 | DATE 9/20/2016

COMPUTED BY PKS

SUBJECT Final Cover Veneer Stability Evaluation | JOB # DAVDCO-16-12 | CHECKED BY

OBJECTIVE: To determine the interface shear strength requirements for the final cover system veneer to satisfy the required factor(s) of safety 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}(Seismic) = 1.0 (If Applicable)

ANALYSIS:

1. Treat the final cover as an infinite slope and use the following equation:

$$FS = \frac{Resisting Force}{Driving Force} = \frac{\dfrac{c}{\gamma_c z_c \cos^2\beta} + \tan\delta\left[1 - \dfrac{\gamma_w (z_c - d_w)}{\gamma_c z_c}\right] - k_s(\tan\beta)(\tan\delta)}{k_s + \tan\beta}$$

(Matasovic, 1991)

where:

FS	=	factor of safety against shallow veneer failure
k_s	=	seismic coefficient (= 0 for static conditions) (= peak ground acceleration for seismic conditions)
γ_c	=	unit weight of final cover material(s) (pcf)
γ_w	=	unit weight of water (62.4 pcf) (pcf)
c	=	cohesion/adhesion along assumed failure surface (psf)
δ	=	interface friction angle along assumed failure surface (degrees)
Z_c	=	depth of final cover (depth to failure surface) (ft)
d_w	=	depth to seepage surface (assumed parallel to slope) (ft)
β	=	slope angle of final cover (degrees)

$$u = \gamma_w (z_c - d_w)$$

*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.

2. Determine minimum interface shear strength as follows:

$$\tau = \sigma \tan\delta + c$$

where:

τ	=	interface shear strength (lbs)
σ	=	normal load (psf)
δ	=	interface friction angle (min. value from analysis or greater)
c	=	cohesion/adhesion (min. value from analysis or greater)

PROJECT	**Davidson County - C&DLF**	SHEET	2/2
		JOB #	DAVDCO-16-12
SUBJECT	**Final Cover Veneer Stability Evaluation**	DATE	9/20/2016
		COMPUTED BY	PKS
		CHECKED BY	GGM

Input Parameters:

Side Slope Angle (β): 9.5 degrees (6.0H:1V Slope) ***Much Steeper than Top Areas***

Final Cover:
- Thickness (z_c): 2.0 ft
- Unit Weight (γ_c): 110 pcf
- Cohesion/Adhesion (c): 0 psf
- Depth to Seepage (d_w): 1.5 ft (= z if Slope is Dry) ***Assumes 6" Head Pressure on Top or 6" Gas Pressure on Bottom***

Seismic Coefficient (k_s): 0 Static Conditions

0.10 Seismic Conditions (= Peak Ground Acceleration For The Site)
(Conservative - per Lat/Long and 2014 USGS Information, actual value is 0.08)

Required Factors of Safety:
- Static: 1.5
- Dynamic: 1.0

Static Conditions:

Interface Friction Angle (δ) (degrees)	Resisting Force	Driving Force	FS	Comment
15	0.23	0.17	1.37	**NO GOOD**
16	0.25	0.17	1.47	**NO GOOD**
17	0.26	0.17	1.57	**OK**
17.7	0.27	0.17	1.64	**OK**
18	0.28	0.17	1.67	**OK**
19	0.30	0.17	1.77	**OK**

Seismic Conditions:

Interface Friction Angle (δ) (degrees)	Resisting Force	Driving Force	FS	Comment
15	0.23	0.27	0.84	**NO GOOD**
16	0.24	0.27	0.90	**NO GOOD**
17	0.26	0.27	0.96	**NO GOOD**
17.7	0.27	0.27	1.00	**OK**
18	0.27	0.27	1.02	**OK**
19	0.29	0.27	1.08	**OK**

Minimum Interface Shear Strength Requirements:

Cohesion/Adhesion (c) (From Above) = 0 psf

Interface Friction Angle (δ) = 17.7 degrees (Use Min. Value From Above or Greater)

Normal Load (σ) (psf)	Interface Shear Strength (τ) (psf)
100	32
200	64
500	160

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Attachment B

Technical Specifications

Alternative Final Cover System Request
Davidson County C&D Landfill
Davidson County, North Carolina

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Technical Specifications

Davidson County C&D Landfill Closure
Davidson County, North Carolina

Prepared for:

Davidson County Integrated Solid Waste Management Department
Lexington, North Carolina

October 2016

NC LIC. NO. C-0828 (ENGINEERING)

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Davidson County C&D Landfill Closure
Davidson County, North Carolina

Technical Specifications

Table of Contents

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SECTION 02110

SITE PREPARATION

Site Preparation: Site Preparation includes clearing, grubbing, and stripping operations which precede the proposed construction.

A. Description

1. General:

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

   b. Principal items of work include:

      1. Notifying all authorities owning utility lines running to or on the property. Protect and maintain all utility lines to remain and cap those that are not required in accordance with instructions of the Utility Companies, and all other authorities having jurisdiction.

      2. Clearing the site within the clearing limits, including removal of grass, brush, shrubs, trees, loose debris, and other encumbrances except for trees to remain.

      3. Boxing and protecting all areas to be preserved.

      4. Disposing from the site all debris resulting from work under this Section.

2. Related Work:

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

Work	Section
Excavation	02222
Embankment	02223

B. Materials

Not Used.

C. Submittals

Not Used.

D. Construction

1. Clearing of the Site:

   a. Clearing limits, as shown on the Contract Drawings, shall be established by the Contractor's Surveyor. Once established, the clearing limits shall be inspected and approved by the Engineer prior to clearing the affected areas.

   b. Before the start of excavation and grading operations, the areas within the clearing limits shown on the Contract Drawings shall be cleared and grubbed.

   c. Clearing shall consist of cutting, removal, and satisfactory disposal of all trees, fallen timber, brush, bushes, rubbish, fencing, and other perishable and objectionable material.

      Should it become necessary to remove a tree, bush, brush, or other plants outside the clearing limits, the Contractor shall do so only after permission has been granted by the Engineer.

   d. Excavation resulting from the removal of trees, roots, and the like shall be filled with suitable material, as approved by the Engineer, and thoroughly compacted per the requirements contained in Section 02223, Embankment, of these Specifications.

   e. In temporary construction easement locations, only those trees and shrubs shall be removed which are in actual interference with excavation or grading work under this Contract, and removal shall be subject to approval by the Engineer. However, the Engineer reserves the right to order additional trees and shrubs removed at no additional cost to the Owner, if such, in his opinion, they are too close to the work to be maintained or have become damaged due to the Contractor's operations.

2. Grubbing:

   a. Grubbing shall consist of the removal and disposal of all stumps, roots, logs, sticks, and other perishable materials to a depth of at least 6 inches below ground surfaces.

   b. Large stumps located in areas to be excavated may be removed during grading operations, subject to the approval of the Engineer.

3. Disposal of Cleared and Grubbed Material:

   No open burning of clearing debris will be allowed on this project. All trees, stumps, roots, bushes, etc. shall be removed from the site and disposed of by the Contractor.

END OF SECTION

SECTION 02222

EXCAVATION

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

A. Description

1. General:

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

a. Clearing and grubbing and removal of topsoil is addressed in Section 02110, Site Preparation, of these Specifications.

2. Related Work:

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

Work	Section
Site Preparation	02110
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 all materials (borrow and/or unsuitable materials included) located with the limits of construction including widening cuts and shaping of slopes necessary for the preparation of roadbeds, 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 (Where Applicable): 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 Material Overexcavation: shall consist of the removal and satisfactory disposal of all unsuitable material located within the limits of construction and below subgrade elevations shown or indicated on the Contract Drawings. Where excavation to the subgrade elevations results in a subgrade or slopes of unsuitable material, the Contractor shall overexcavate such material to below the grades shown or indicated on the Contract Drawings or as otherwise directed by the Engineer and CQA Engineer.

B. Materials

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

C. Submittals

Not 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. Except for certain erosion and sedimentation control measures and other areas designated to impound water, all areas shall be graded to drain.

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:

    a. 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 Engineer and CQA Engineer in advance and backfilled with compacted Embankment in accordance with Section 02223, Embankment, of these Specifications.

    b. No additional payment will be made for such overexcavation and backfill 1 foot or less than the finished subgrade as this is considered superficial.

    c. Where overexcavation of unsuitable material is greater than 1 foot beneath the finished subgrade, payment shall be made on a unit price basis for overexcavation and backfill and the measured quantity shall include the entire excavation quantity below the finished subgrade elevations. The unit price for overexcavation and backfill shall include disposal of unsuitable materials.

15. All cuts shall be brought to the grade and cross section shown or indicated 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

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SECTION 02223

EMBANKMENT

Embankment: Embankment is the on-site compacted fill that provides berms and backfill around structures and piping. Intermediate cover is also covered under this section.

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 2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

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

4. Quality Assurance:

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

5. Definitions:

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

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

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

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

B. Materials

1. Embankment materials shall consist of clean well-graded natural soil classified as SP, SW, SM, SC, ML, or CL (ASTM D 2487) containing no topsoil or other deleterious material. Other material classifications may be approved by the Engineer.

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

C. Submittals

Not Used.

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. Except for certain erosion and sedimentation control measures and other areas designated to impound water, all areas shall be graded to drain.

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 3H:1V, the subgrade shall be benched to a minimum depth of 6 inches and the Embankment shall be placed in horizontal lifts.

14. Backfilling for Structures and Piping:

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

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

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

Table 1: Required Embankment Properties

Item	Required % Standard Proctor (ASTM D698)[2]	Required Moisture Content[3]	Maximum Lift Thickness (Compacted) (inches)
Embankment Beneath Structures and Roads[1]	100	+/- 2% of Optimum (std. Proctor)	8
Embankment	95	As Required for Compaction	8
Backfill Around Structures	95		8
Backfill in Pipe Trenches	95		6
Unclassified Fill	N/A	N/A	N/A
Intermediate Cover	See Note 5	N/A	N/A

Notes:

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

END OF SECTION

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SECTION 02240

GEOTEXTILES

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

A. Description

1. General:

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

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

2. Related Work:

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

Work	Section
Erosion and Sedimentation Control	02270

3. Reference Standards:

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

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a 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 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
ASTM D 6241	Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50 mm Probe.
AASHTO M 288	Standard Specification for Geotextiles.

B. Materials

1. General:

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

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

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

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

C. Submittals

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

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

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

3. Seaming Procedures: Submit proposed seaming procedures including proposed method and equipment.

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

D. Construction

1. Shipping, Handling, and Storage:

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

2. 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:

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

4. Seams:

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

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

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

is used. The minimum seam allowance for all other seam types shall be 1.0 inches.

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

5. Repair Procedures:

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

b. Slopes Flatter Than 6H:1V: 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 of 6H:1V or Steeper: 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:

a. Except when designed to remain exposed, Geotextiles shall be covered in a timely manner to limit potential UV damage. Unless otherwise approved by the Engineer, covering shall occur within 30 days of installation. Extension of this time may be considered by the Engineer based on weather conditions (i.e. prolonged cloud cover during 30 day period) or technical information provided by the Manufacturer that would justify an extension.

(1) The Engineer may conduct sampling and testing of any Geotextiles exposed for a period longer than allowed to verify the material properties. The cost associated with this testing and the subsequent repair(s) shall be bourne solely by the Contractor regardless of the test results. In no case will the maximum length of exposure be greater than 60 days without verification of material properties.

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

Table 1: Required Geotextile Properties

Property	Test Method	Units	Value[1]
			Type GT-S
Geotextile Construction (NW = Nonwoven) (W = Woven)	-----	-----	NW[2] or W[3]
Mass per Unit Area (Unit Weight)	ASTM D 5261	oz/yd^2	N/A
UV Resistance (500 hrs)	ASTM D 4355	%	70
Strength Class[4]	AASHTO M 288	Class	2
Tensile Properties:	ASTM D 4632		
Grab Strength		lbs	160 (NW) 250 (W)
Grab Elongation		%	≥ 50 (NW) < 50 (W)
Puncture Resistance	ASTM D 6241	lbs	410 (NW) 950 (W)
Trapezoidal Tear Strength	ASTM D 4533	lbs	55 (NW) 90 (W)
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70+
Permittivity	ASTM D 4491	sec^{-1}	1.0

Notes:

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

END OF SECTION

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SECTION 02250

SOIL LINER

Soil Liner: The Soil Liner(s) serves as a hydraulic containment barrier in the final cover system.

A. Description

1. General:

   a. The Contractor shall furnish all labor, material, and equipment to complete installation of the Soil Liner including borrowing, hauling, screening, mixing, stockpiling, discing, compacting, drying or wetting, removal of surface water, removal of all previously placed material affected by adverse weather conditions or construction disturbance, final grading and sealing, and all necessary and incidental items as detailed or required to complete the Soil Liner, all in accordance with the Contract Drawings and these Specifications.

   b. The Contractor shall provide suitable soil from an on-site or off-site borrow site that meets all requirements outlined in these Specifications for Soil Liner.

      Off-site borrow sources shall be approved in advance by the Engineer. The Contractor shall be responsible for all submittals required for Engineer approval of off-site borrow sources.

2. Related Work:

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

Work	Section
Excavation	02222
Embankment	02223
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 422	Standard Test Method for Particle Size Analysis of Soils.
ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.
ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

4. Quality Assurance:

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

B. Materials

All material for Soil Liner shall conform to the requirements shown in Table 1 of this section.

C. Submittals

The Contractor shall submit the following to the CQA Engineer:

1. Before approval is given to proceed with test fill construction, the Contractor shall submit descriptive information on compaction equipment to be used for construction of the Soil Liner.

2. Off-Site Borrow Sources (If Applicable):

a. For each off-site borrow source for Soil Liner soils, the Contractor shall provide the following information at least four weeks prior to placement of the Soil Liner:

(1) The name, location, and owner of proposed borrow site, including a topographic map and location map of the site.

(2) A certification submitted by an independent Registered Professional Engineer that the proposed borrow site contains a minimum of double the in-place volume of Soil Liner required to complete the work.

(3) A certification submitted by an independent Registered Professional Engineer that the proposed borrow soils meet the requirements for Soil Liner outlined in these Specifications. Certification shall include the following minimum testing and test frequency:

Test (Test Method)	Quantity (Min.)
Atterberg Limits (ASTM D 4318)	10
Grain Size (with Hydrometer) (ASTM D 422)	10
Standard Proctor (ASTM D 698)	5
Natural Moisture Content (ASTM D 2216)	10
Hydraulic Conductivity (Lab Remolded) (ASTM D 5084)	5

Testing samples for certification shall be obtained from well distributed locations within the proposed borrow area. All test data shall be submitted with the soil certification.

b. The Contractor shall be responsible for maintaining quality of the Soil Liner borrow source throughout construction and shall ensure that the borrow soil meets the project criteria outlined in these Specifications. The Contractor shall cooperate with the CQA Engineer so that the CQA Engineer has unlimited access to the borrow area during construction for the purposes of sampling and testing borrow soil.

c. If the borrow source does not meet the requirements outlined in these Specifications, the Contractor shall be responsible for providing an alternative borrow source at no cost to the Owner.

3. Survey Results

Survey results for Soil Liner subgrade shall be submitted for review prior to placement of Soil Liner. After completion of a segment of Soil Liner, survey results shall be submitted for review prior to placement of overlying layers.

D. Construction

1. General:

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

   b. The Contractor shall place and compact the Soil Liner to the lines and grades shown on the Contract Drawings with the exception that a 0.15 foot overbuild at the Contractor's expense is allowed. Thickness requirements are minimum values. The Contractor will perform all surveys necessary to establish and verify lines and grades for all Soil Liner.

2. Borrow Soils:

   a. The Contractor may haul borrow soil to an on-site stockpile area. Unless otherwise allowed by the Engineer, borrow soil cannot be hauled directly to the containment area for placement and compaction unless each load is monitored and approved by the CQA Engineer prior to loading at the borrow site.

   b. Any borrow soil not meeting the requirements for Soil Liner shall be rejected and removed from the project site by the Contractor at no cost to the Owner.

3. Test Fill Construction:

   The Contractor shall construct a test fill prior to construction of Soil Liner. The test fill shall be at least 20 feet wide by 50 feet long and shall be compacted in lifts to the full design thickness. The Contractor shall use materials and equipment for test fill construction that the Contractor intends to use during construction.

   No Soil Liner construction may be performed until the test fill construction is confirmed to be adequate in accordance with the Project CQA Manual.

   The Contractor shall amend construction techniques or equipment in order to meet all criteria outlined for Soil Liner in these Specifications at no cost to the Owner.

4. Subgrade Preparation:

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

   b. Prior to placement of Soil Liner, 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 subgrade materials revealed before or during the in-place compaction shall be removed as directed by the CQA Engineer and replaced with suitable materials.

5. Placement and Compaction:

a. All Soil Liner shall be placed in loose lifts no greater than the height of the feet on compaction equipment to be used. The loose Soil Liner shall be free from clods or rocks which exceed the sizes in Table 1. Where excessive sized clods do occur, the Contractor shall break up the clods using methods approved by the CQA Engineer.

b. Lift compaction shall be performed with an appropriately heavy, properly ballasted, penetrating-foot compactor. Compaction equipment shall be the same as used in the test fill, unless otherwise approved by the Engineer.

Each lift shall be compacted prior to placement of succeeding lifts. The maximum lift thickness shall be as shown in Table 2. In confined areas, mechanical equipment, suitable for small areas and capable of achieving the density requirements, shall be required.

c. The exposed surface of Soil Liner shall be protected from adverse weather conditions or desiccation of the soil. This is commonly done by rolling the surface of the Soil Liner with a smooth-drum roller at the end of each work day. Alternative means of protecting the Soil Liner may be employed by the Contractor.

d. The in-place Soil Liner shall conform to the requirements shown in Table 2 of this section. If Soil Liner 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.

e. Any Soil Liner surface which is smooth, has a moisture content outside of the specified moisture content range, as defined by ASTM D 698, or exhibits evidence of desiccation cracking ½ inch deep or greater, shall be scarified to a depth of 1 to 3 inches and brought to a proper moisture content prior to placement of a subsequent lift. This includes any Soil Liner surface that was previously seal rolled for protection.

f. No Soil Liner shall be placed or compacted when soil temperatures are so low as to produce ice lenses in the Soil Liner borrow soil.

g. Soil Liner placed on side slopes shall be placed and compacted in lifts which are parallel to the slope. Lift criteria shall be as described herein.

h. Surfaces not properly maintained shall be repaired by the Contractor at no cost to the Owner. A suitable surface for geosynthetics construction shall be a surface maintained at the specified compaction and moisture content criteria provided in these Specifications.

i. Locations of control stakes, in-place density tests, or other samples in the Soil Liner shall be patched with compacted Soil Liner or sodium bentonite compacted and hydrated in the holes.

7. Surveying:

a. Before placement of a segment of Soil Liner, the Soil Liner subgrade 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 the top of the Soil Liner subgrade slopes at grades specified on the Contract Drawings.

b. After completion of a segment of Soil Liner, but before installation of subsequent layers, the Soil Liner shall be surveyed on 100 foot centers and at slope breaks to ensure:

(1) The specified thickness has been achieved.

(2) The top of the Soil Liner slopes at grades specified on the Contract Drawings; and

(3) Soil Liner 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 expense if required by the Engineer.

This work shall be performed at the Contractor=s cost by a registered surveyor.

Table 1:Soil Liner Material Requirements

Property	Test Method	Value
Visual Classification	ASTM D 2488	Clean natural fine-grained soil free from organics, debris, or other detrimental material. Soil type as required to achieve the hydraulic conductivity criteria.
Clod Size	-----	Maximum = ¾ inch (or less if required to achieve hydraulic conductivity criteria)
Gradation	ASTM D 422	Max. = 1½ inches
Atterberg Limits	ASTM D 4318	As required based on soil type.
Hydraulic Conductivity (Lab Remolded) (Compacted Soil Barrier)	ASTM D 5084[3]	$\leq$ 1 x 10^{-5} cm/s at a density of $\geq$ 95% maximum standard dry density and a moisture content $\geq$ optimum moisture content[4]

Table 2: In-Place Soil Liner Requirements

Property	Test Method	Value
Density	ASTM D 6938[1]	≥ 95% maximum standard dry density[4]
Moisture Content	ASTM D 6938[2]	≥ optimum moisture content[4]
Maximum Lift Thickness (Compacted): (Compacted Soil Barrier)	-----	9 inches
Hydraulic Conductivity (Shelby Tube): (Compacted Soil Barrier)	ASTM D 5084[3]	≤ 1 x 10^{-5} cm/s
Completed Thickness: (Compacted Soil Barrier)	Survey	18 inches minimum

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937.
2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959.
3. Maximum effective confining pressure and maximum hydraulic gradient as follows. Backpressure as recommended by ASTM D 5084. Modifications of the maximum hydraulic gradient may be allowed by the Engineer depending on actual hydraulic conductivity values.

Material	Maximum Effective Confining Pressure (psi)	Maximum Hydraulic Gradient
Compacted Soil Barrier (k ≤ 1 x 10^{-5} cm/s)	5	15

4. Or as otherwise determined by remolded samples to achieve hydraulic conductivity criteria.

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
Drainage Geocomposite	02712
Geosynthetic Clay Liner	02776
LLDPE Geomembrane	02778
Revegetation	02930
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 2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

4. Quality Assurance:

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

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 SM, SC, ML, ML-CL, or CL (ASTM D 2487). Alternatives to these requirements must be approved in advance by the Engineer. The Engineer shall verify that the upper geotextile of the underlying Drainage Geocomposite is anticipated to perform acceptably as a filter in contact with the selected soil(s).

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.

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. Where applicable, 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 and compaction of VSL shall be performed only when the CQA Engineer is informed by the Contractor of intent to perform such work.

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

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

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

c. On slopes of 6H:1V or steeper, VSL shall be placed and spread from the bottom up unless otherwise approved by the Engineer. No material shall be dumped down a slope.

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

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

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

   a. VSL shall not be placed when conditions are warm enough to produce excessive wrinkles in the underlying geosynthetics. Likewise, VSL shall not be placed when conditions are cold enough to produce tension in the underlying geosynthetics.

   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. A hand auger or similar method may be used to check for thickness at each location.

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 registered surveyor.

END OF SECTION

SECTION 02270

EROSION AND SEDIMENTATION CONTROL

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

A. Description

1. General:

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

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

2. Related Work:

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

Work	Section
Rolled Erosion Control Products	02275
Stormwater Systems	02720
Revegetation	02930

3. Reference Standards:

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

ASTM D 3786	Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

B. Materials

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

   Permanent drainage channels, diversions, swales, and ditches 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 1.33 lb/linear foot steel (preferred) or wood with a minimum length of 5 feet. Steel posts shall be "U" or "T"-type. Wood posts shall have a minimum diameter of 4-inches.

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

3. Geotextiles:

   Geotextiles placed where shown on the Contract Drawings shall be 6 oz/SY non-woven polypropylene or other product as approved by the Engineer.

4. Stone Filters:

   Stone filters shall be constructed as shown on the Contract Drawings.

5. Down Pipes:

Down pipes shall be constructed as shown on the Contract Drawings. Pipe materials shall meet the requirements of Section 02720, Stormwater Systems, of these Specifications.

6. Rip Rap:

Rip Rap shall conform to the requirements of the NCDOT and meet the requirements shown on the Contract Drawings.

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

9. Temporary and Permanent Ground Cover:

The Contractor shall provide temporary or permanent ground cover (or other acceptable measure(s)) adequate to restrain erosion on erodible slopes or other areas within 21 calendar days following completion of any phase of grading. The Contractor shall provide permanent ground cover for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following the completion of construction.

C. Submittals

The Contractor shall submit the following to the Engineer:

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

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

D. Construction

1. Establishment of Erosion and Sedimentation Control Measures:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. Graded Slopes and Fills:

The angle for graded slopes and fills shall be no greater than the angle that can be retained by vegetated cover or other adequate measures.

4. Finish Grading:

All disturbed areas shall be uniformly graded to the lines, grades, and elevations shown on the Contract Drawings. Except for certain erosion and sedimentation control measures and other areas designated to impound water, all areas shall be graded to drain. 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.

5. Revegetation:

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

6. 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	90 x 90
Grab Elongation	ASTM D 4632	%	20 (Max.)
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	80
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	30+
Permittivity	ASTM D 4491	sec^{-1}	0.05

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

END OF SECTION

SECTION 02275

ROLLED EROSION CONTROL PRODUCTS

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

A. Description

1. General:

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

2. Related Work:

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

Work	Section
Erosion and Sedimentation Control	02270
Revegetation	02930

3. Reference Standards:

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

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 6475	Standard Test Method for Measuring Mass per Unit Area of Erosion Control Blankets.
ASTM D 6524	Standard Test Method for Measuring the Resiliency of Turf Reinforcement Mats.
ASTM D 6525	Standard Test Method for Measuring Nominal Thickness of Permanent Erosion Control Products.
ASTM D 6566	Standard Test Method for Measuring Mass per Unit Area of Turf Reinforcement Mats.
ASTM D 6818	Standard Test Method for Ultimate Tensile Properties of Turf Reinforcement Mats.

B. Materials

1. General:

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

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

2. Erosion Control Blanket (ECB):

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

   Flexterra Flexible Growth Media (FGM), as manufactured by Profile Products, applied at a minimum rate of 3,500 lbs/acre is an acceptable substitute for ECB to be placed on 2H:1V slopes (a minimum rate of 3,000 lbs/acre shall be used on 3H:1V slopes).

3. Turf Reinforcement Mat (TRM):

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

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

C. Submittals

The Contractor shall submit the following to the Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for

each RECP attesting that each RECP meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of each RECP to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Installation Guidelines/Instructions: The Manufacturer's guidelines/instructions for installation 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 Contract Drawings and/or the Manufacturer's installation guidelines/instructions for installation details.

4. Installation - Slopes:

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

5. Maintenance:

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

Table 1: Required Rolled Erosion Control Product Properties

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

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

END OF SECTION

SECTION 02712

DRAINAGE GEOCOMPOSITE

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

A. Description

1. General:

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

2. Related Work:

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

Work	Section
Vegetative Soil Layer	02258
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) are hereby made a part of these specifications.

ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
ASTM D 4218	Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique.
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus.
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
ASTM D 6241	Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50 mm Probe.
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 7005	Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.
ASTM D 7466	Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.

4. Quality Control:

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

5. Quality Assurance:

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

B. Materials

1. General:

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

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

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

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

4. Final Cover Drainage Geocomposite:

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

   Alternatively, the Final Cover DGC may consist of a series of small diameter pipes bonded on both sides within two non-woven geotextiles. This material shall be Draintube or approved equal meeting the geotextile and geocomposite properties as shown in Table 1 of this section.

5. Toe drain components shall be as shown on the Contract Drawings.

C. Submittals

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

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

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

3. Seaming Procedures:

Submit proposed seaming procedures including proposed method and equipment.

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

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

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

D. Construction

1. Shipping, Handling, and Storage:

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

2. Failing CQA Material Control Tests:

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

3. Installation:

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

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

c. Orientation: If the DGC transmits flow in a predominant direction (typically along the roll length), then the DGC shall be installed with the predominant flow direction laid approximately perpendicular to contour lines (i.e. in the direction of

the slope) or as specified by the Engineer. Otherwise, DGC shall be installed with the machine direction (along the roll length) generally in the direction of flow or as specified by the Engineer.

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

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

4. Seams:

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

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

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

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

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

5. Repairs:

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

the patch shall be spot sewn or heat bonded to the upper geotextile of the damaged material. A geotextile patch, spot sewn or heat bonded to the damaged material, may be used where damage is to only that portion of the DGC.

6. Install toe drains where shown or indicated on the Contract Drawings.

7. Cover Placement:

   a. DGC shall be covered in a timely manner to limit potential UV damage. Unless otherwise approved by the Engineer, covering shall occur within 30 days of installation. Extension of this time may be considered by the Engineer based on weather conditions (i.e. prolonged cloud cover during 30 day period) or technical information provided by the Manufacturer that would justify an extension.

      (1) The Engineer may conduct sampling and testing of any DGC exposed for a period longer than allowed to verify the material properties. The cost associated with this testing and the subsequent repair(s) shall be bourne solely by the Contractor regardless of the test results. In no case will the maximum length of exposure be greater than 60 days without verification of material properties.

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

Table 1: Required Drainage Geocomposite Properties

Property	Test Method	Units	Value
Geonet:			
Thickness	ASTM D 5199	inches	0.25 (See Note 1)
Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 1603/D 4218	%	2-3
Geotextile:			
Mass per Unit Area (Unit Wt.)	ASTM D 5261	oz/yd^2	6
Tensile Properties: Grab Strength Grab Elongation	ASTM D 4632	 lbs %	 160 $\geq$ 50
Puncture Resistance	ASTM D 6241	lbs	410
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70+
Permittivity	ASTM D 4491	sec^{-1}	1.0
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	70
Geocomposite:			
Ply Adhesion	ASTM D 7005	lb/inch	2.0 Typ. 1.0 Min. Avg.
Transmissivity: (Final Cover)	ASTM D 4716	$m^3/m/sec$	 1.0×10^{-3} (See Note 2)
Interface Shear Strength (Peak)[3, 4] (Final Cover)	ASTM D 5321 ASTM D 6243 (GCL)	psf	 64 psf (Load = 200 psf)

Notes:

1. A thicker geonet may be required depending on transmissivity requirements.
2. Final Cover:
   Conduct test for transmissivity at a normal compressive load of 500 psf and at a hydraulic gradient of 0.10 after a seating period of at least 24 hours. Boundary conditions are soil (sand) interface on the upper geotextile and textured LLDPE geomembrane (or GCL) against the lower geotextile.
3. DGC shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.

4. The specified interface shear strength requirement is based on a finished slope no steeper than 6H:1V. Steeper slopes will require evaluation by the Engineer.

Table 2: Required Manufacturer Quality Control Tests

Property	Test Method	Minimum Test Frequency
Geonet:		
Thickness	ASTM D 5199	50,000 ft^2
Density	ASTM D 1505	50,000 ft^2
Carbon Black Content	ASTM D 1603/D 4218	50,000 ft^2
Geotextile:		
Mass Per Unit Area	ASTM D 5261	200,000 ft^2
Tensile Properties	ASTM D 4632	200,000 ft^2
Puncture Resistance	ASTM D 6241	200,000 ft^2
Apparent Opening Size (AOS)	ASTM D 4751	600,000 ft^2
Permittivity	ASTM D 4491	600,000 ft^2
UV Resistance	ASTM D 4355	600,000 ft^2
Geocomposite:		
Ply Adhesion	ASTM D 7005	100,000 ft^2
Transmissivity[1]	ASTM D 4716	100,000 ft^2 (See Note 2)

Notes:

1. Conduct transmissivity tests in accordance with the criteria given in Table 1.
2. The required Manufacturer's quality control testing for transmissivity may be reduced to one test per resin lot or one test per 500,000 ft^2 (whichever provides the larger number of tests) if the minimum measured transmissivity is at least 50% greater than specified.

Table 3: Required Contractor Quality Control Tests

Property	Test Method	Minimum Test Frequency
Interface Shear Strength	ASTM D 5321 ASTM D 6243 (GCL)	(See Note 1)

Notes:

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

   Final Cover:

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

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

   For tests involving textured geomembranes, the laboratory shall also report the asperity height (ASTM D 7466) for the material samples used in the actual direct shear tests.

END OF SECTION

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SECTION 02720

STORMWATER SYSTEMS

Stormwater Systems: Stormwater 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 Stormwater 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

3. Reference Standards:

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

ASTM C 76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
ASTM C 150	Standard Specification for Portland Cement.
ASTM D 1248	Standard Specification for Polyethylene Plastics Molding and Extrusion Materials For Wire and Cable.
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
ASTM D 3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
AASHTO M 36	Specification for Corrugated Steel Pipe.

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

B. Materials

1. Reinforced Concrete Pipe (RCP):

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

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

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

2. Corrugated Metal Pipe (CMP):

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

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

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

   d. Coupling Bands: CMP shall be firmly joined by coupling bands in accordance with the manufacturer's recommendations. These bands shall be not more than two nominal sheet thicknesses lighter than the thickness of the pipe to be connected and in no case lighter than 0.052 inches.

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

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

3. Corrugated Polyethylene (CPE) Pipe:

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

4. Flared End Sections:

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

C. Submittals

The Contractor shall submit the following to the Engineer:

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

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

D. Construction

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

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

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

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

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

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

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

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

END OF SECTION

SECTION 02776

GEOSYNTHETIC CLAY LINER (GCL)

Geosynthetic Clay Liner (GCL): The GCL is used as a secondary hydraulic barrier within the final cover system.

A. Description

1. General:

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

2. Related Work:

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

Work	Section
Drainage Geocomposite	02712
CQA Manual	Attached

3. Reference Standards:

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

ASTM D 5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.
ASTM D 5890	Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
ASTM D 5891	Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.
ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.
ASTM D 6243	Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.

ASTM D 6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
ASTM D 6768	Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.
ASTM D 7466	Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.

4. Quality Control:

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

5. Quality Assurance:

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

6. Manufacturer Qualifications:

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

7. 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.

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 GCL.

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

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

B. Materials

1. General:

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

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

2. Needle Detection and Removal Procedures:

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

3. Physical Properties:

Physical properties of GCL shall be as shown in Table 1 of this section. Granular sodium bentonite used for overlaps and repairs shall have the same properties as the bentonite used in the GCL.

C. Submittals

The Contractor shall submit the following to the CQA Engineer:

1. Pre-Installation Requirements:

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

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

b. Qualifications:

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

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

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

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

e. Installation Procedures and Drawings:

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

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

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

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

2. Post-Installation Requirements:

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

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

b. Completed Manufacturer's and Workmanship Warranties.

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

D. Construction

1. Shipping , Handling, and Storage:

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

2. Failing CQA Material Control Tests:

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

3. Installation of GCL:

   a. The surface 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, standing water, debris, and deleterious materials.

   b. Before an individual panel of GCL 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.

   c. 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.

   d. The GCL shall not be placed during precipitation. Any GCL that becomes hydrated prior to covering shall be removed and replaced at Contractor expense if required by the Engineer. Likewise, if the subgrade below the GCL becomes excessively wet and unstable as determined by the CQA Engineer, it shall be dried and recompacted, and replaced if needed.

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

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

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

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

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

j. Any GCL that is torn, punctured, or otherwise damaged shall be repaired or replaced as directed by the CQA Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of GCL placed over (or alternatively under) the damaged areas and shall overlap the existing GCL a minimum of 12 inches from any point of the damage. Granular sodium bentonite shall be added around the perimeter of the damaged area and between the patch and the GCL at a rate of approximately 0.25 lbs/linear foot. Small tears or punctures may be repaired by the addition of granular sodium bentonite alone where approved by the CQA Engineer.

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

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

4. Cover Placement:

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

Table 1: Required GCL Properties

Property	Test Method	Units	Value
Clay:			
Bentonite Swell Index	ASTM D 5890	ml/2g	24
Bentonite Fluid Loss	ASTM D 5891	ml	$\leq$ 18
GCL:			
Bentonite Content	ASTM D 5993	psf	0.75 (@ 0% moisture)
Tensile Strength	ASTM D 6768	lbs/in	30
Peel Strength	ASTM D 6496	lbs/in	7.5 Avg. Peak 5.3 Min. Avg.
Hydraulic Conductivity	ASTM D 5887	cm/sec	$\leq 5 \times 10^{-9}$
Internal Shear Strength[1] (Hydrated) (Peak)	ASTM D 6243	psf	500
Interface Shear Strength (Hydrated) (Peak)[2, 3]	ASTM D 6243	psf	64 psf (Load = 200 psf)

Notes:

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

Table 2: Required Manufacturer Quality Control Tests

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

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

Table 3: Required Contractor Quality Control Tests

Property	Test Method	Minimum Test Frequency
Interface Shear Strength	ASTM D 6243 (GCL)	(See Note 1)

Notes:
1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:
   Final Cover:
   A. Textured LLDPE-GM (30 mil) (or GCL) against existing cover soils (intermediate cover);
   B. Drainage Geocomposite against textured LLDPE-GM (30 mil) (or GCL); and
   C. Vegetative Soil Layer against Drainage Geocomposite.

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

   For tests involving textured geomembranes, the laboratory shall also report the asperity height (ASTM D 7466) for the material samples used in the actual direct shear tests.

END OF SECTION

SECTION 02778

LLDPE GEOMEMBRANE

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

A. Description

1. General:

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

2. Related Work:

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

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

3. Reference Standards:

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

ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
ASTM D 7466	Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.
GRI GM9	Cold Weather Seaming of Geomembranes.
GRI GM17	Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.
GRI GM19	Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

4. Quality Control:

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

   b. The Geomembrane Installer shall follow the procedures and requirements described in the accompanying Project CQA Manual during installation of LLDPE-GM including performing and documenting trial seams, nondestructive and destructive Quality Control tests, and repairs.

5. Quality Assurance:

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

6. Manufacturers Qualifications:

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

7. Installer Qualifications:

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

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

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

8. Warranties:

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

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

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

B. Materials

1. General:

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

The LLDPE-GM shall be supplied in rolls which shall have a minimum width of 22 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest

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

2. LLDPE-GM Materials:

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

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

3. Extrusion Resin/Typical Extrudate:

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

4. Texturing:

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

C. Submittals

The Contractor shall submit the following to the CQA Engineer:

1. Pre-Installation Requirements:

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

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

   b. Qualifications:

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

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

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

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

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

e. Installation Procedures and Drawings:

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

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

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

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

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

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

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

2. Post-Installation Requirements:

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

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

b. Completed Manufacturer's and workmanship warranties.

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

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

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

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

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

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

2. Failing CQA Material Control Tests:

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

3. Subgrade Preparation:

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

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

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

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

4. LLDPE-GM Placement:

a. Weather Conditions:

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

b. Method of Placement:

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

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

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

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

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

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

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

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

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

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

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

(12) When tying into existing LLDPE-GM, excavation of previously installed geosynthetics shall be performed in a manner that minimizes damage to the existing geosynthetics and as approved by the Engineer. All damage to the existing geosynthetics shall be repaired by the Geosynthetics Installer at the Contractor's sole expense.

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

c. Pipe Penetrations:

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

5. Field Seams:

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

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

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

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

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

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

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

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

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

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

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

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

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

n. Excessive wrinkles along geomembrane seams shall be minimized. Fish-mouths or large wrinkles shall be cut along the ridge of the wrinkle to allow a flat overlap, which shall be re-seamed. All cuts shall be repaired with a patch.

o. All seams (including repairs) shall meet or exceed the requirements of GRI GM19 and 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 shall be extrusion seamed to the underlying LLDPE-GM. This method should be used to repair lengths of extrusion or hot wedge seams.

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

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

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

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

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

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

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

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

8. Surveying:

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

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

(2) Location of all repairs/patches;

(3) Location of all destructive test locations; and

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

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

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

9. Cover Placement:

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

Table 1: Required LLDPE-GM Properties

Property	Test Method	Units	Value
			30 mil Textured
Interface Shear Strength (Peak)[1, 2, 3]	ASTM D 5321	psf	64 psf (Load = 200 psf)

Notes:

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

Table 2: Required Contractor Quality Control Tests

Property	Test Method	Minimum Test Frequency
Interface Shear Strength	ASTM D 5321	(See Note 1)

Notes:

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

   Final Cover:

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

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

For tests involving textured geomembranes, the laboratory shall also report the asperity height (ASTM D 7466) for the material samples used in the actual direct shear tests.

Table 3: Required Seam Strength Properties

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

Notes:

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

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

END OF SECTION

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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
Excavation	02222
Embankment	02223
Protective Cover	02256
Erosion and Sedimentation Control	02270
Rolled Erosion Control Products	02275

3. Warranty:

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

B. Materials

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

2. Fertilizer: Unless otherwise defined by specific soil tests, supply commercial fertilizer 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. 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.

7. Application rates, seed types, and other requirements shall be in accordance with Table 1 of this section.

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 at 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. <u>Seeding:</u>

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.

(3) For slopes not steeper than 3H:1V and as an option to using binder to secure mulch, use a mulch anchoring tool operated along the contour of the slope.

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 (See Note 1)
Lime	-----	4,000 lbs/acre
Fertilizer (10-10-10)	-----	1,000 lbs/acre
Seed:		
Permanent:	Kentucky 31 Tall Fescue Sericea Lespedeza[3] Kobe Lespedeza Seasonal Nurse Crop[2]	250 lbs/acre 30 lbs/acre 10 lbs/acre See Note 2
Temporary:	Seasonal Nurse Crop[2]	See Note 2
Mulch	-----	4,000 - 5,000 lbs/acre
Binder	-----	400 gallons/acre

Notes:

1. Application rates and/or chemical analysis shall be confirmed or established by a soil test(s).
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

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SECTION 13253

LANDFILL GAS VENTS

Landfill Gas Vents: Landfill Gas Vents are installed within the landfill in order to vent landfill gas, 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 the 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
Soil Liner	02250
Vegetative Soil Layer	02258
Drainage Geocomposite	02712
Geosynthetic Clay Liner	02776
LLDPE Geomembrane	02778

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 (collection pipe) PVC Pipe meeting the requirements of ASTM D 1785. The pipe schedule and diameter shall be as shown on the Contract Drawings.

2. Backfill for Landfill Gas Vents shall be NCDOT #57 stone (non-calcareous).

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

C. Submittals

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

D. Construction

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

3. All waste materials removed during construction of Landfill Gas Vents shall be disposed of on site in the C&D landfill as directed by the Owner and Engineer. No weighing or tipping fee will be required.

END OF SECTION

Attachment C

CQA Manual

Alternative Final Cover System Request
Davidson County C&D Landfill
Davidson County, North Carolina

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Attachment D

Closure Drawings

Alternative Final Cover System Request
Davidson County C&D Landfill
Davidson County, North Carolina

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DAVIDSON COUNTY INTEGRATED SOLID WASTE MANAGEMENT
LEXINGTON, NORTH CAROLINA

DAVIDSON COUNTY C&D LANDFILL CLOSURE

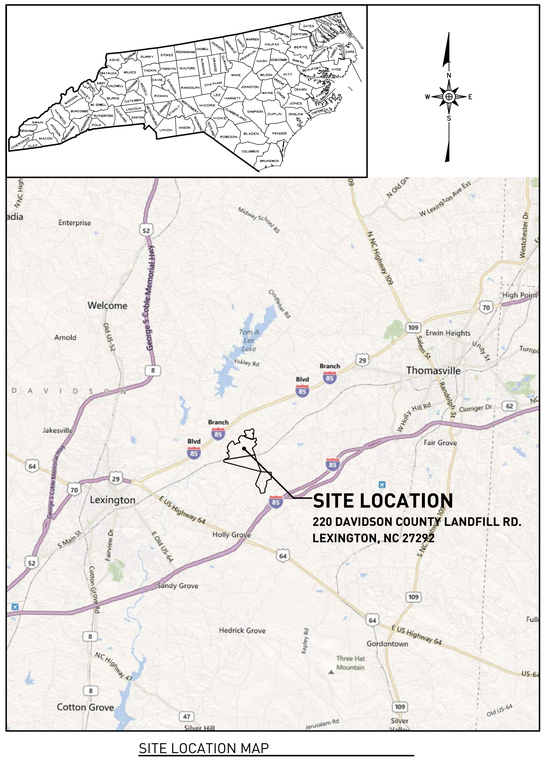
CONSTRUCTION DRAWINGS
OCTOBER 2016

SEAL

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021088 PETER K. SCHENCK
9/29/2016

SEAL

REV.	DATE	DESCRIPTION

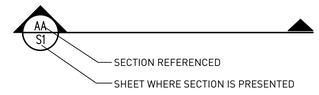


SITE LOCATION MAP
NOT TO SCALE

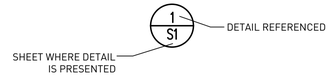
RIVER BASIN: YADKIN

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	-	TITLE - COVER SHEET
2	S1	EXISTING CONDITIONS
3	S2	INTERMEDIATE COVER GRADING PLAN
4	S3	FINAL COVER GRADING AND DRAINAGE PLAN
5	FC1	FINAL COVER DETAILS
6	EC1	EROSION AND SEDIMENTATION CONTROL DETAILS (SHEET 1 OF 2)
7	EC2	EROSION AND SEDIMENTATION CONTROL DETAILS (SHEET 2 OF 2)

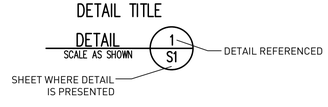
STANDARD SECTION LOCATION
CALLOUT (SHEET AND DETAIL)



STANDARD DETAIL CALLOUT



STANDARD DETAIL LABEL AND CALLOUT



STANDARD REVISION
CALLOUT (SHEET AND DETAIL)

NOTIFICATION OF LAND RESOURCES SEDIMENT AND EROSION CONTOL SELF-INSPECTION PROGRAM:

THE SEDIMENTATION POLLUTION CONTROL ACT WAS AMENDED IN 2006 TO REQUIRE THAT PERSONS RESPONSIBLE FOR LAND-DISTURBING ACTIVITIES INSPECT A PROJECT AFTER EACH PHASE OF THE PROJECT TO MAKE SURE THAT THE APPROVED EROSION AND SEDIMENTATION CONTROL PLAN IS BEING FOLLOWED. RULES DETAILING THE DOCUMENTATION OF THESE INSPECTIONS TOOK EFFECT OCTOBER 1, 2010. THE SELF-INSPECTION PROGRAM IS SEPARATE FROM THE WEEKLY SELF-MONITORING PROGRAM OF THE NPDES STORMWATER PERMIT FOR CONSTRUCTION ACTIVITIES. THE FOCUS OF THE SELF-INSPECTION REPORT IS THE INSTALLATION AND MAINTENANCE OF EROSION AND SEDIMENTATION CONTROL MEASURES ACCORDING TO THE APPROVED PLAN. THE INSPECTIONS MUST BE CONDUCTED AFTER EACH PHASE OF THE PROJECT AND CONTINUED UNTIL PERMANENT GROUND COVER IS ESTABLISHED IN ACCORDANCE WITH NCGS 113A-54.1.1 AND 15A NCAC 4B.0131. THE SELF-INSPECTION REPORT FORM IS AVAILABLE AS AN EXCEL SPREADSHEET FROM http://www.dlr.enr.state.nc.us/pages/sedimentation new.html. IF YOU HAVE QUESTIONS OR CANNOT ACCESS THE FORM, PLEASE CONTACT THE LAND QUALITY SECTION AT (336) 771-5000 (WINSTON-SALEM REGIONAL OFFICE).

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

FOR BIDDING
NOT FOR CONSTRUCTION

SAFETY NOTE:
Contractor shall be solely responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work. Contractor shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection.

POTENTIAL BORROW SITE
OLD HIGHWAY 29
LEACHATE STORAGE TANK FACILITY
FORMER OFFICE
SITE ENTRANCE
LOCATION FOR SITE MEETINGS
PHASE 2 SCALE/SCALEHOUSE
RICH FORK CREEK
AREA 2 CELL 2
AREA 2 CELL 1 (ACTIVE)
MSW LANDFILL (PHASE 2 AREA 1)
BORROW & STOCKPILE AREAS
FACILITY BOUNDARY (TYP.)
PROPOSED FUTURE MSW LANDFILL UNITS
OVERHEAD POWER LINE AND EASEMENT
ROAD PERMANENTLY CLOSED AT RAILROAD CROSSING
CITIZEN'S CONVENIENCE CENTER
200' EXISTING RAILROAD RIGHT OF WAY (NC RAILROAD)
LEACHATE STORAGE POND
DUKE POWER TRANSMISSION LINE RIGHT OF WAY
AREA 1
AREA 3
AREA 2
MSW LANDFILL (PHASE 1) (CLOSED)
C&D LANDFILL (INACTIVE, AS OF JUNE 2016)
WEST BORROW AREA (SEE NOTE 1)
SITE ENTRANCE 1000 LOWER LAKE ROAD (APPROX.) THOMASVILLE, NC 27360
LOWER LAKE ROAD
PHASE 2 LFG HEADER PIPE
WHITE GOODS/SCRAP METAL/TIRES HANDLING AREA
SCALE/SCALEHOUSE
DAVIDSON GAS PRODUCERS, LLC ELECTRICAL GENERATION FACILITY (INCL. BLOWERS AND FLARE)
HOUSEHOLD HAZARDOUS WASTE (HHW) BUILDING
RECYCLING BUILDING
OFFICE/MAINTENANCE BUILDING
AREA 1
ADDITIONAL PROPERTY OWNED BY DAVIDSON COUNTY
CLOSED HOLLY GROVE LANDFILL
HAMBY CREEK
DAVIDSON COUNTY LANDFILL ROAD
TEMPORARY EMERGENCY STORM DEBRIS SITE
AREA II
CONVENIENCE CENTER
ROY LOPP ROAD
SITE ENTRANCE 925 ROY LOPP ROAD (APPROX.) LEXINGTON, NC 27292 (SEE NOTE 2)

0 400' 800' 1200'

SAFETY NOTE:
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FOR BIDDING
NOT FOR CONSTRUCTION

LEGEND

- EXISTING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- FACILITY BOUNDARY (PROPERTY LINE)
- LIMIT OF LINER (EXISTING LINED UNITS)
- LIMIT OF LINER (FUTURE LINED UNITS)
- APPROXIMATE EXISTING WASTE LIMITS (UNLINED UNITS)
- WETLAND BOUNDARY (SEE REFERENCE 2)
- STREAM (SEE REFERENCE 2)
- EXISTING OVERHEAD POWER LINE AND EASEMENT
- MW-8D EXISTING MONITORING WELL
- SW-3 EXISTING SURFACE WATER SAMPLING POINT

NOTES

1. BORROW SOIL FOR THE C&D CLOSURE PROJECT IS LOCATED IN THE WEST BORROW AREA. CONTRACTOR SHALL PROTECT NEARBY LFG HEADER PIPE.
2. SITE ENTRANCE AT ROY LOPP ROAD HAS A BRIDGE WHICH IS WEIGHT LIMITED. USE ENTRANCE ON LOWER LAKE ROAD FOR HEAVY EQUIPMENT.

REFERENCES

1. OVERALL TOPOGRAPHY PER NORTH CAROLINA DEPARTMENT OF TRANSPORTATION, CONTOUR AND ELEVATION DATA GENERATED FROM LIGHT DETECTION AND RANGING (LIDAR) DATA OBTAINED FROM THE NORTH CAROLINA FLOOD MAPPING PROGRAM AND DATED SEPTEMBER 2004. TOPOGRAPHY IN ACTIVE C&D AND MSW AREAS FROM AERIAL SURVEY DATED 5/7/16 BY SPATIAL DATA, INC., HIGH POINT, NC.
2. WETLAND SURVEY BY LEXINGTON LAND SURVEYING, DATED 3/28/01.
3. WETLANDS AND STREAM LOCATIONS ON SOUTHEAST SIDE OF C&D LANDFILL FROM DELINEATION PERFORMED BY CAROLINA ECOSYSTEMS, INC., FEBRUARY 2009, AND SURVEYED BY MICHAEL GREEN ASSOCIATES, P.A., FEBRUARY 2009.

PREPARED FOR:

DAVIDSON COUNTY
INTEGRATED SOLID
WASTE MANAGEMENT
LEXINGTON,
NORTH CAROLINA

PREPARED BY:
NC LIC. NO. C-0828 (ENGINEERING)
SMITH+ GARDNER
ENGINEERS
14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

SEAL
NORTH CAROLINA PROFESSIONAL SEAL 031055 ENGINEER PATRICK K. SCHEER
9/29/2016

SEAL

REV.	DATE	DESCRIPTION

PROJECT TITLE:

DAVIDSON COUNTY
C&D LANDFILL CLOSURE
CONSTRUCTION DRAWINGS

DRAWING TITLE:

EXISTING CONDITIONS

DESIGNED: P.K.S.	PROJECT NO: DAVDCO 16-12
DRAWN:	SCALE: AS SHOWN
APPROVED: GGM	DATE: OCT. 2016
FILENAME: DAVDCO-D0818	
SHEET NUMBER: 2	DRAWING NUMBER: S1

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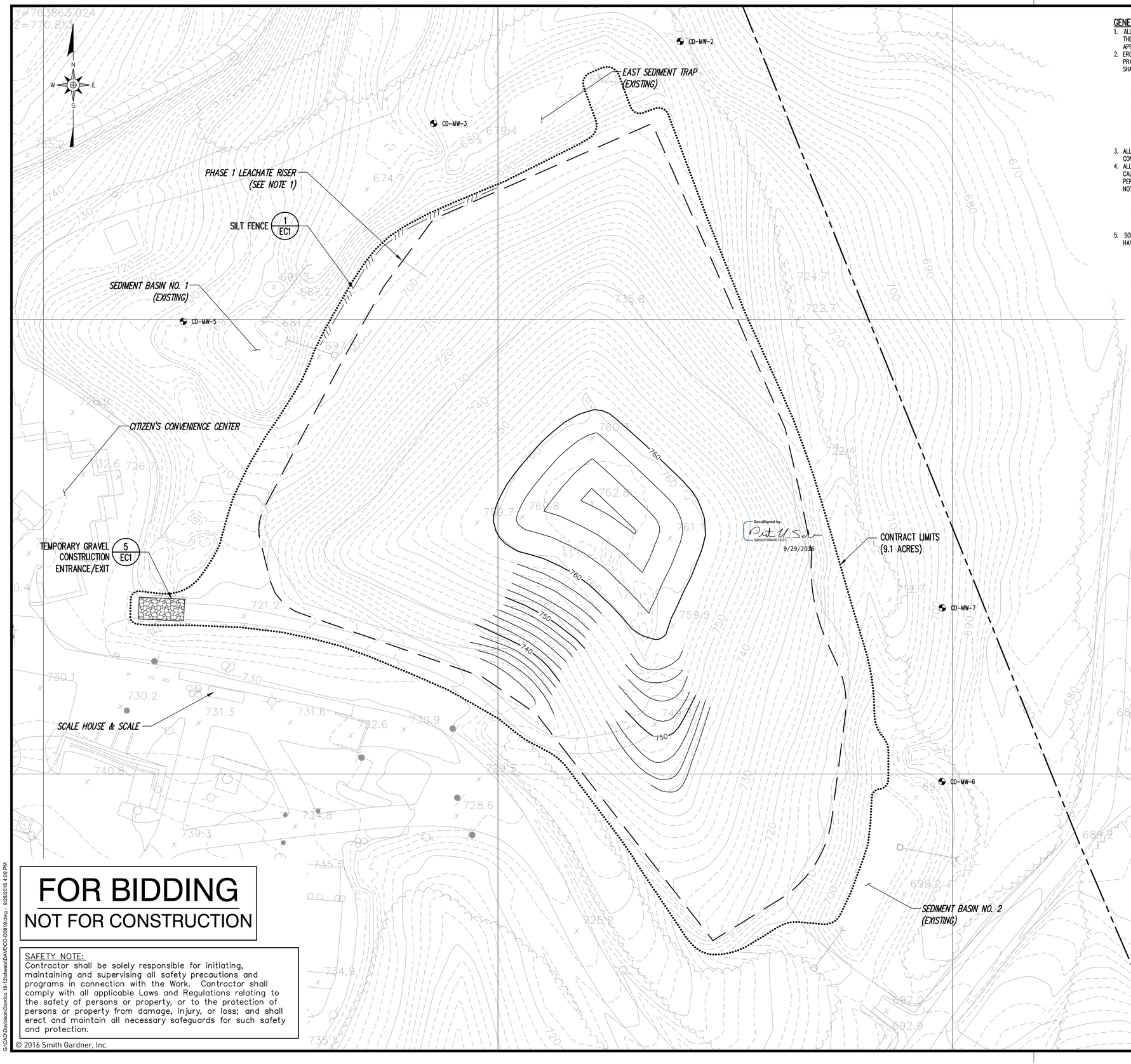
9/29/2016



GENERAL EROSION AND SEDIMENTATION CONTROL NOTES

1. ALL EROSION AND SEDIMENTATION CONTROL WORK SHALL BE IN ACCORDANCE WITH THE LATEST EDITION OF THE NORTH CAROLINA EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL AS WELL AS APPLICABLE REGULATIONS.
2. EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE ESTABLISHED PRIOR TO, OR AS SOON AS PRACTICAL THEREAFTER, ANY LAND CLEARING OR CONSTRUCTION ACTIVITIES MAY BEGIN. THE CONTRACTOR SHALL FOLLOW THE FOLLOWING SCHEDULE:
   A. CONTACT THE NCDENR DIVISION OF ENERGY, MINERAL, AND LAND RESOURCES, LAND QUALITY SECTION, (WINSTON-SALEM REGIONAL OFFICE: (336) 771-5000).
   B. FLAG THE CLEARING LIMITS.
   C. INSTALL TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT.
   D. CLEAR THE VEGETATED PORTION OF THE SITE AND INSTALL SILT AND STONE FILTER FENCING (WHERE REQUIRED) PRIOR TO STRIPPING/GRUBBING.
   E. REMOVE/STOCKPILE SOIL AS REQUIRED FOR CONSTRUCTION.
   F. PERFORM FINE GRADING AND ESTABLISH PERMANENT VEGETATION ON COMPLETED AREAS.
   G. AFTER STABILIZATION, REMOVE SILT FENCING AND OTHER TEMPORARY MEASURES AS DIRECTED BY THE OWNER AND INSTALL PERMANENT VEGETATION ON THE DISTURBED AREAS.
3. ALL EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE CONSTRUCTED ACCORDING TO THE CONTRACT DRAWINGS AND SPECIFICATIONS.
4. ALL EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE INSPECTED AT LEAST ONCE EVERY SEVEN CALENDAR DAYS AND WITHIN 24 HOURS AFTER ANY STORM EVENT OF GREATER THAN 0.5 INCHES OF RAIN PER 24 HOUR PERIOD AND APPROPRIATE MAINTENANCE CONDUCTED. MAINTENANCE SHALL INCLUDE, BUT NOT BE LIMITED TO:
   A. THE REMOVAL AND SATISFACTORY DISPOSAL OF TRAPPED OR DEPOSITED SEDIMENTS FROM BASINS, TRAPS, BARRIERS, FILTERS, AND/OR DRAINAGE FEATURES/DEVICES;
   B. REPLACEMENT OF FILTER FABRICS USED FOR SILT FENCES UPON LOSS OF EFFICIENCY; AND
   C. REPLACEMENT OF ANY OTHER COMPONENTS WHICH ARE DAMAGED OR CANNOT SERVE THE INTENDED USE.
5. SOIL STABILIZATION SHALL BE ACHIEVED ON ANY AREA OF THE SITE WHERE LAND-DISTURBING ACTIVITIES HAVE TEMPORARILY OR PERMANENTLY CEASED ACCORDING TO THE FOLLOWING SCHEDULE:
   A. ALL PERIMETER DIKES, SWALES, DITCHES, PERIMETER SLOPES, AND ALL SLOPES STEEPER THAN 3 HORIZONTAL TO 1 VERTICAL (3H:1V) SHALL BE PROVIDED TEMPORARY OR PERMANENT STABILIZATION WITH GROUND COVER AS SOON AS PRACTICABLE BUT IN ANY EVENT WITHIN 7 CALENDAR DAYS FROM THE LAST LAND-DISTURBING ACTIVITY.
   B. ALL OTHER DISTURBED AREAS SHALL BE PROVIDED TEMPORARY OR PERMANENT STABILIZATION WITH GROUND COVER AS SOON AS PRACTICABLE BUT IN ANY EVENT WITHIN 14 CALENDAR DAYS FROM THE LAST LAND-DISTURBING ACTIVITY.
   C. BASINS, TRAPS, CHANNELS, AND DIVERSIONS SHALL BE LINED WITH ANCHORED ROLLED EROSION PRODUCTS OR RIP RAP AND/OR VEGETATED UPON CONSTRUCTION.
   D. PERMANENT GROUND COVER FOR ALL DISTURBED AREAS SHALL BE ESTABLISHED WITHIN 15 WORKING DAYS OR 90 CALENDAR DAYS (WHICHEVER IS SHORTER) FOLLOWING COMPLETION OF CONSTRUCTION OR DEVELOPMENT.

LEGEND

- 690 — EXISTING GROUND CONTOUR (10' INTERVAL)
- EXISTING GROUND CONTOUR (2' INTERVAL)
- 700 — PROPOSED SUBGRADE CONTOUR (10' INTERVAL)
- PROPOSED SUBGRADE CONTOUR (2' INTERVAL)
- /// — SILT FENCE
- PROPERTY LINE
- LIMIT OF WASTE (APPROXIMATE)
- CONSTRUCTION (CONTRACT) LIMITS
- E — OVERHEAD POWER LINE
- UTILITY EASEMENT
- CD-MW-6 — MONITORING WELL

NOTES

1. LEAVE LEACHATE RISER ACCESSIBLE UPON COMPLETION OF PROJECT.

REFERENCES

1. OVERALL TOPOGRAPHY PER NORTH CAROLINA DEPARTMENT OF TRANSPORTATION, CONTOUR AND ELEVATION DATA GENERATED FROM LIGHT DETECTION AND RANGING (LIDAR) DATA OBTAINED FROM THE NORTH CAROLINA FLOOD MAPPING PROGRAM AND DATED SEPTEMBER 2004. TOPOGRAPHY IN ACTIVE C&D AND MSW AREAS FROM AERIAL SURVEY DATED 5/7/16 BY SPATIAL DATA, INC., HIGH POINT, NC.
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0 50' 100' 150'

FOR BIDDING
NOT FOR CONSTRUCTION

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PREPARED FOR:

DAVIDSON COUNTY INTEGRATED SOLID WASTE MANAGEMENT LEXINGTON, NORTH CAROLINA

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)
SMITH+ GARDNER
ENGINEERS
14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

SEAL

NORTH CAROLINA PROFESSIONAL SEAL 032095 ENGINEER PATRICK K. SCHROEDER
9/29/2016

SEAL

REV.	DATE	DESCRIPTION

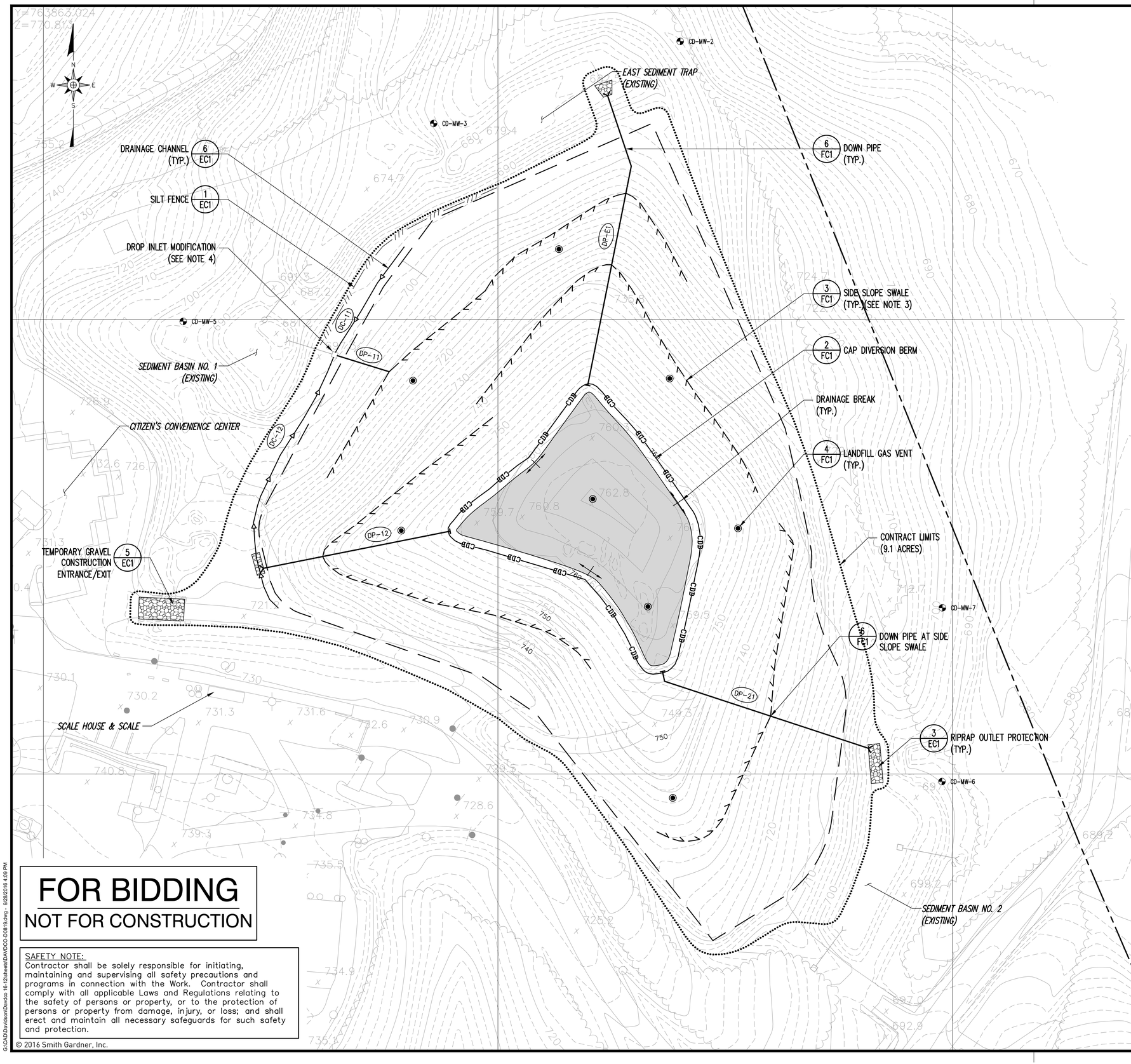
PROJECT TITLE:

DAVIDSON COUNTY C&D LANDFILL CLOSURE CONSTRUCTION DRAWINGS

DRAWING TITLE:

INTERMEDIATE COVER GRADING PLAN

DESIGNED: P.K.S.	PROJECT NO: DAVDCO 16-12
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED: GGM	DATE: OCT. 2016
FILENAME: DAVDCO-D0819	
SHEET NUMBER: 3	DRAWING NUMBER: S2



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   B. FLAG THE CLEARING LIMITS.
   C. INSTALL TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT.
   D. CLEAR THE VEGETATED PORTION OF THE SITE AND INSTALL SILT AND STONE FILTER FENCING (WHERE REQUIRED) PRIOR TO STRIPPING/GRUBBING.
   E. REMOVE/STOCKPILE SOIL AS REQUIRED FOR CONSTRUCTION.
   F. PERFORM FINE GRADING AND ESTABLISH PERMANENT VEGETATION ON COMPLETED AREAS.
   G. AFTER STABILIZATION, REMOVE SILT FENCING AND OTHER TEMPORARY MEASURES AS DIRECTED BY THE OWNER AND INSTALL PERMANENT VEGETATION ON THE DISTURBED AREAS.
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   B. REPLACEMENT OF FILTER FABRICS USED FOR SILT FENCES UPON LOSS OF EFFICIENCY; AND
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LEGEND

- 690 — EXISTING GROUND CONTOUR (10' INTERVAL)
- EXISTING GROUND CONTOUR (2' INTERVAL)
- 700 — PROPOSED SUBGRADE CONTOUR (10' INTERVAL)
- PROPOSED SUBGRADE CONTOUR (2' INTERVAL)
- PROPERTY LINE
- LIMIT OF WASTE (APPROXIMATE)
- CONSTRUCTION (CONTRACT) LIMITS
- 300' BUFFER
- E — OVERHEAD POWER LINE
- UTILITY EASEMENT
- LANDFILL GAS VENT
- MW-4 MONITORING WELL
- SB-2 EXISTING SEDIMENT BASIN
- RD-E EXISTING ROCK DAM
- DC-A DRAINAGE CHANNEL
- DP-12 DOWN PIPE
- CDB CAP DIVERSION BERM (INSIDE CREST OF BERM)
- SIDE SLOPE SWALE
- SILT FENCE
- AREA OF GEOSYNTHETICS (FINAL COVER SYSTEM TYPE 2A ONLY)

NOTES

1. LEAVE LEACHATE RISER ACCESSIBLE UPON COMPLETION OF PROJECT.
2. GRADES SHOWN REPRESENT TOP OF INTERMEDIATE COVER.
3. GRADE SIDE SLOPE SWALES TOWARD DOWN PIPE INLETS AT 4% MINIMUM SLOPE.
4. CUT SIDE OF EXISTING DROP INLET TO ALLOW DIRECT DISCHARGE OF DOWN PIPE INTO DROP INLET.

REFERENCES

1. OVERALL TOPOGRAPHY PER NORTH CAROLINA DEPARTMENT OF TRANSPORTATION, CONTOUR AND ELEVATION DATA GENERATED FROM LIGHT DETECTION AND RANGING (LIDAR) DATA OBTAINED FROM THE NORTH CAROLINA FLOOD MAPPING PROGRAM AND DATED SEPTEMBER 2004. TOPOGRAPHY IN ACTIVE C&D AND MSW AREAS FROM AERIAL SURVEY DATED 5/7/16 BY SPATIAL DATA, INC., HIGH POINT, NC.
2. WETLAND SURVEY BY LEXINGTON LAND SURVEYING, DATED 3/28/01.
3. WETLANDS AND STREAM LOCATIONS ON SOUTHEAST SIDE OF C&D LANDFILL FROM DELINEATION PERFORMED BY CAROLINA ECOSYSTEMS, INC., FEBRUARY 2009, AND SURVEYED BY MICHAEL GREEN ASSOCIATES, P.A., FEBRUARY 2009.

0 50' 100' 150'

FOR BIDDING
NOT FOR CONSTRUCTION

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G:\CAD\Davidson\Davdco 16-12\sheets\DAVDCO-D0819.dwg - 9/28/2016 4:09 PM

PREPARED FOR:

DAVIDSON COUNTY INTEGRATED SOLID WASTE MANAGEMENT LEXINGTON, NORTH CAROLINA

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)
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SEAL

NORTH CAROLINA PROFESSIONAL SEAL 031066 ENGINEER PATRICK K. SCHIFFLETT
Signed by
9/29/2016

SEAL

REV.	DATE	DESCRIPTION

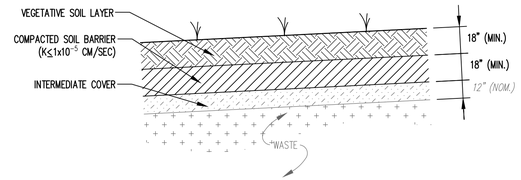
PROJECT TITLE:

DAVIDSON COUNTY C&D LANDFILL CLOSURE CONSTRUCTION DRAWINGS

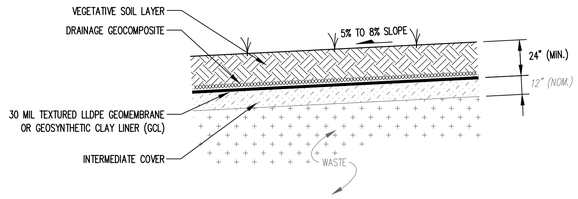
DRAWING TITLE:

FINAL COVER GRADING AND DRAINAGE PLAN

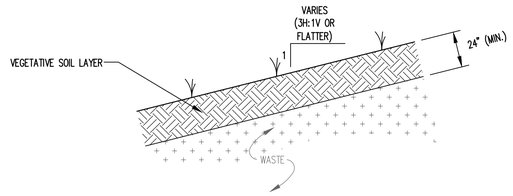
DESIGNED: P.K.S.	PROJECT NO: DAVDCO 16-12
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED: GGM	DATE: OCT. 2016
FILENAME: DAVDCO-D0819	
SHEET NUMBER: 4	DRAWING NUMBER: S3



REGULATORY FINAL COVER SYSTEM (TYPE 1)



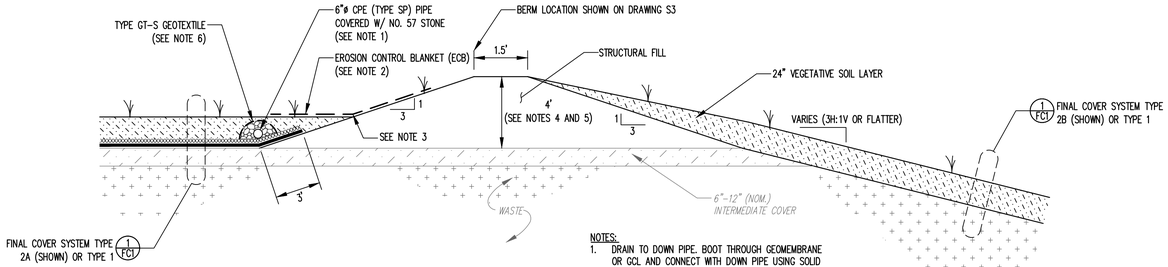
ALTERNATIVE FINAL COVER SYSTEM – TOP SLOPES (TYPE 2A)



ALTERNATIVE FINAL COVER SYSTEM – SIDE SLOPES (TYPE 2B)

FINAL COVER SYSTEM CROSS SECTIONS

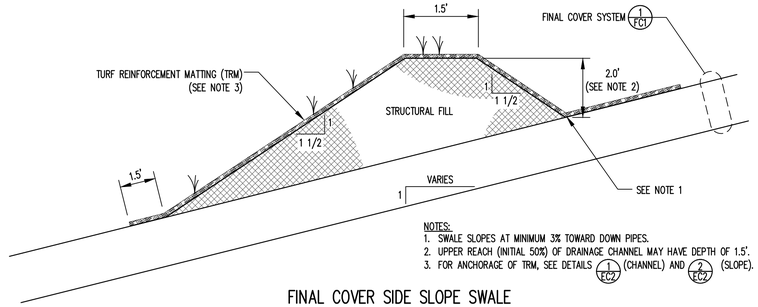
DETAIL 1 FC1 — NOT TO SCALE



CAP DIVERSION BERM

DETAIL 2 FC1 — NOT TO SCALE

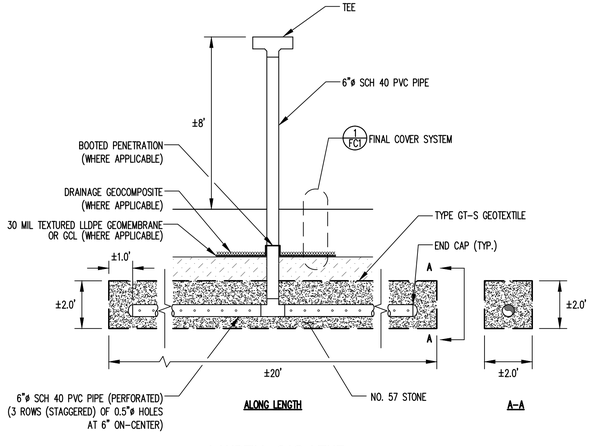
NOTES:
1. DRAIN TO DOWN PIPE. BOOT THROUGH GEOMEMBRANE OR GCL AND CONNECT WITH DOWN PIPE USING SOLID (TYPE S) PIPE AND APPROPRIATE WATERTIGHT FITTINGS.
2. FOR ANCHORAGE OF ECB, SEE DETAIL 3 FC2.
3. PROVIDE 1.5% MINIMUM SLOPE ALONG INSIDE OF BERM TOWARD DOWN PIPE.
4. INCREASE BERM HEIGHT NEAR DOWN PIPES TO MAINTAIN TOP OF BERM AT 3.0' MINIMUM ABOVE DOWN PIPE INVERT.
5. FOR FINAL COVER SYSTEM TYPE 1, CONSTRUCT BERM USING COMPACTED SOIL BARRIER.
6. HEAT BOND EDGES TO DRAINAGE GEOCOMPOSITE.



NOTES:
1. SWALE SLOPES AT MINIMUM 3% TOWARD DOWN PIPES.
2. UPPER REACH (INITIAL 50%) OF DRAINAGE CHANNEL MAY HAVE DEPTH OF 1.5'.
3. FOR ANCHORAGE OF TRM, SEE DETAILS 1 FC2 (CHANNEL) AND 2 FC2 (SLOPE).

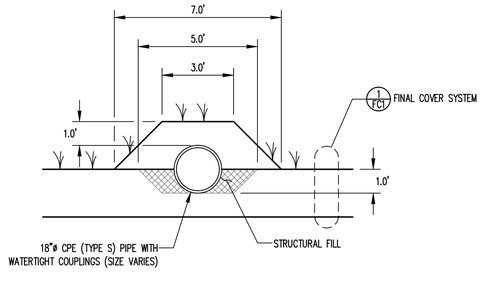
FINAL COVER SIDE SLOPE SWALE

DETAIL 3 FC1 — NOT TO SCALE



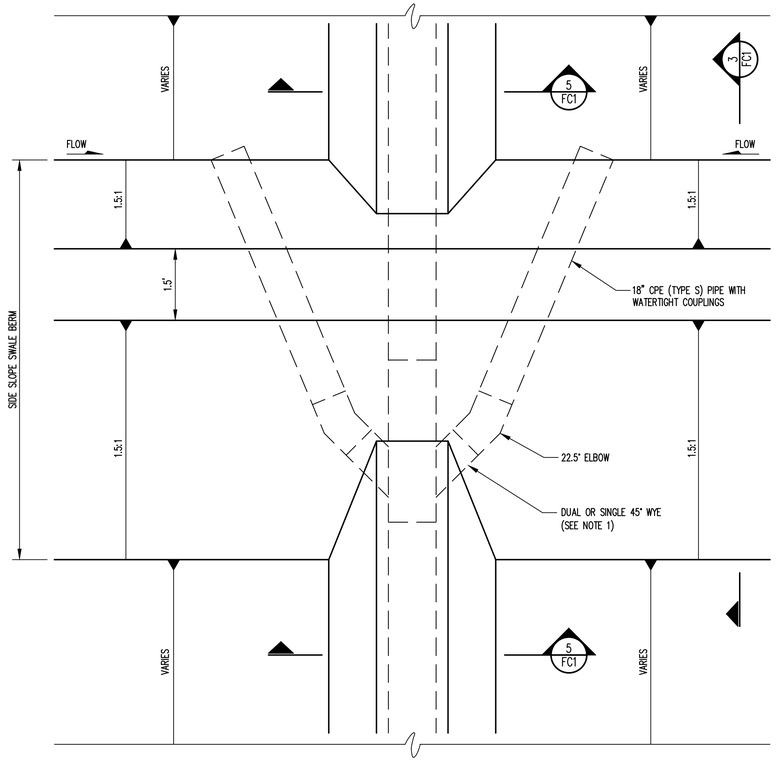
LANDFILL GAS VENT

DETAIL 4 FC1 — NOT TO SCALE



DOWN PIPE ON SLOPE

DETAIL 5 FC1 — NOT TO SCALE



NOTES:
1. DEPENDING ON LOCATION AND SIZE OF DOWN PIPE, WYE FITTING MAY BE SINGLE OR DUAL AND MAY BE A REDUCING WYE. TERMINATE WITH TEE AT LOW POINT ABOVE BERM WHEN DOWN PIPE IS NOT TO BE EXTENDED VERTICALLY.

DOWN PIPE AT SIDE SLOPE SWALE

DETAIL 6 FC1 — NOT TO SCALE

FOR BIDDING
NOT FOR CONSTRUCTION

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PREPARED FOR:

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SEAL

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021006 Registered to PETER K. SCHEER
9/29/2016

SEAL

REV.	DATE	DESCRIPTION

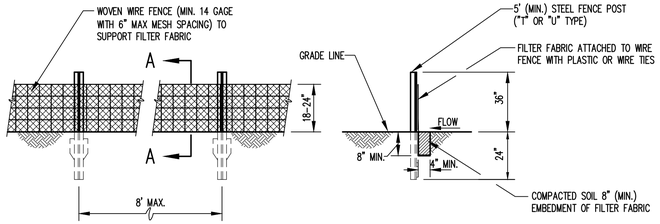
PROJECT TITLE:

DAVIDSON COUNTY C&D LANDFILL CLOSURE CONSTRUCTION DRAWINGS

DRAWING TITLE:

FINAL COVER DETAILS

DESIGNED: P.K.S.	PROJECT NO: DAVDCO 16-12
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED: GGM	DATE: OCT. 2016
FILENAME: DAVDCO-D0820	
SHEET NUMBER: 5	DRAWING NUMBER: FC1



ELEVATION

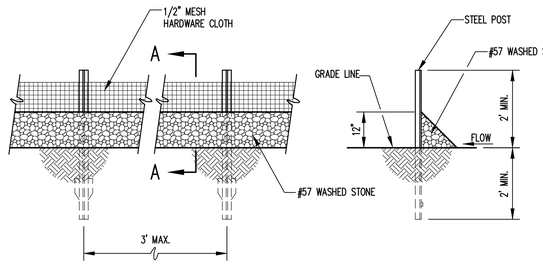
SECTION A–A

SILT FENCE

DETAIL 1 / EC1

NOT TO SCALE

NOTE:
1. SEDIMENT SHALL BE REMOVED WHEN IT REACHES HALF THE HEIGHT OF THE FENCE.



ELEVATION

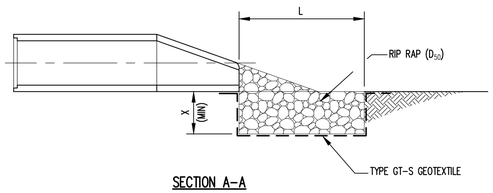
SECTION A–A

STONE FILTER FENCE

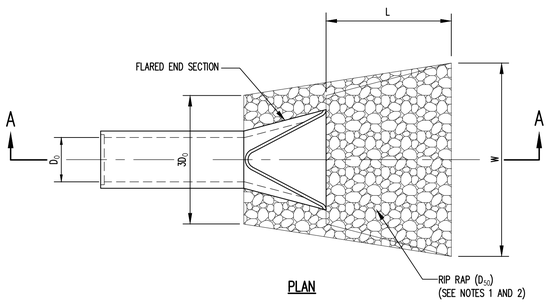
DETAIL 2 / EC1

NOT TO SCALE

NOTE:
1. PLACE 10' SECTION OF STONE FILTER FENCE AT LOW POINTS ALONG SILT FENCE AND WHERE DIRECTED BY THE ENGINEER.



SECTION A–A



PLAN

RIP RAP OUTLET PROTECTION

DETAIL 3 / EC1

NOT TO SCALE

NOTES:
1. D_{50} REFERS TO THE MINIMUM REQUIRED AVERAGE STONE SIZE.
2. RECYCLED CONCRETE (IF AVAILABLE ON–SITE) MAY BE USED AS AN ALTERNATIVE TO RIP RAP.

RIP RAP OUTLET PROTECTION SCHEDULE					
PIPE/CHANNEL	D_0 (INCHES)	L (FEET)	W (FEET)	D_{50} (INCHES)	X (FEET)
DP–12	18	20	16	6	1.0
DP–21	18	40	16	6	1.0
DP–E1	18	14	16	6	1.0
*EXTEND RIP RAP ACROSS BOTTOM WIDTH OF CHANNEL					

SPECIFICATIONS:

1. GENERAL:

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 THE SEEDING SCHEDULE.
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 THE SEEDING SCHEDULE.
   (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 THE SEEDING SCHEDULE.
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, WHERE APPLICABLE.
   (1) SPREAD MULCH IN A CONTINUOUS BLANKET AT THE RATE SPECIFIED IN THE SEEDING SCHEDULE.
   (2) IMMEDIATELY FOLLOWING SPREADING MULCH, SECURE WITH EVENLY DISTRIBUTED BINDER AT THE RATE SPECIFIED IN THE SEEDING SCHEDULE.
   (3) FOR SLOPES NOT STEEPER THAN 3H:1V AND AS AN OPTION TO USING BINDER TO SECURE MULCH, USE A MULCH ANCHORING TOOL OPERATED ALONG THE CONTOUR OF THE SLOPE.

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.

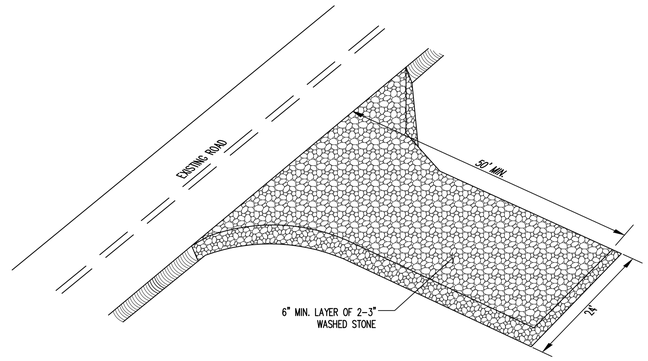
SEEDING SCHEDULE		
MATERIAL	SEED TYPE	APPLICATION RATE
LIME	–	4,000 LBS/ACRE
FERTILIZER (10–10–10)	–	1,000 LBS/ACRE
SEED PERMANENT (SEE NOTE 4)	KENTUCKY 31 TALL FESCUE SERICEA LESPEDEZA KOBE LESPEDEZA SEASONAL NURSE CROP	250 LBS/ACRE 30 LBS/ACRE 10 LBS/ACRE SEE NOTE 2
TEMPORARY	SEASONAL NURSE CROP	SEE NOTE 2
MULCH	–	4,000–5,000 LBS/ACRE
BINDER	–	400 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.

VEGETATIVE STABILIZATION

DETAIL 4 / EC1

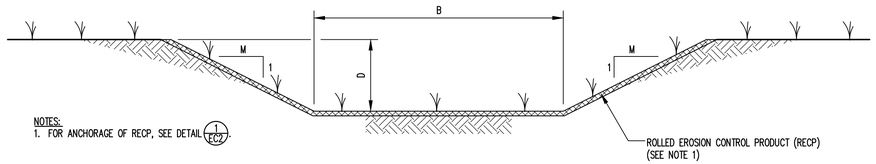
NOT TO SCALE



TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT

DETAIL 5 / EC1

NOT TO SCALE



RECP LINED CHANNELS

DRAINAGE CHANNEL

DETAIL 6 / EC1

NOT TO SCALE

DRAINAGE CHANNEL SCHEDULE				
DRAINAGE CHANNEL NO.	LINING	B (FT)	D (FT)	M
DC–11	TRM*	0	1.5	3
DC–12	TRM	4.0	2.0	3
*TRM= TURF REINFORCED MATTING				

FOR BIDDING

NOT FOR CONSTRUCTION

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PREPARED FOR:

DAVIDSON COUNTY INTEGRATED SOLID WASTE MANAGEMENT LEXINGTON, NORTH CAROLINA

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

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SEAL

NORTH CAROLINA PROFESSIONAL SEAL 021005 ENGINEER PETER K. SCHWAB

9/29/2016

SEAL

REV.	DATE	DESCRIPTION

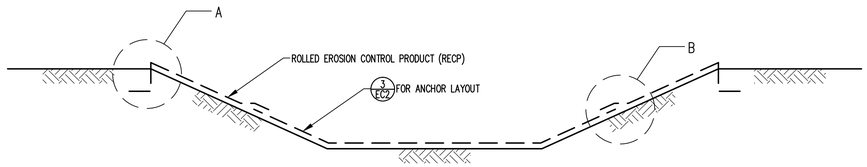
PROJECT TITLE:

DAVIDSON COUNTY C&D LANDFILL CLOSURE CONSTRUCTION DRAWINGS

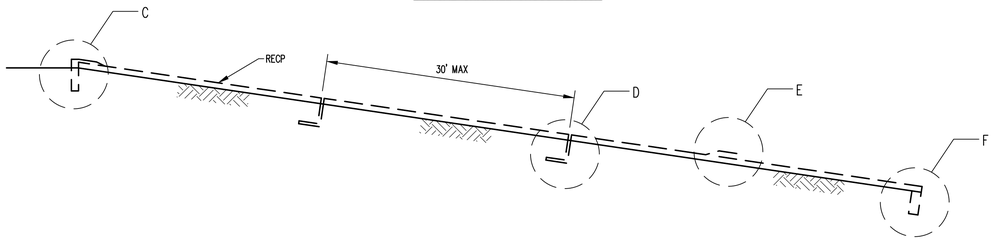
DRAWING TITLE:

EROSION AND SEDIMENTATION CONTROL DETAILS (SHEET 1 OF 2)

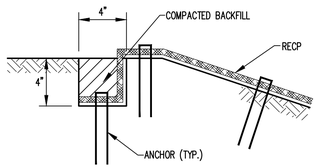
DESIGNED: P.K.S.	PROJECT NO: DAVDCO 16-12
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED: GSm	DATE: OCT. 2016
FILENAME: DAVDCO-D0820	
SHEET NUMBER: 6	DRAWING NUMBER: EC1



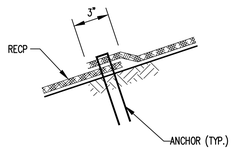
TYPICAL CHANNEL CROSS SECTION



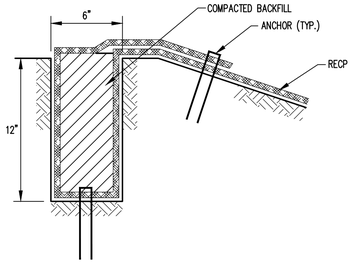
TYPICAL CHANNEL PROFILE



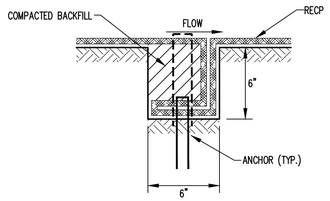
A. LONGITUDINAL ANCHOR TRENCH



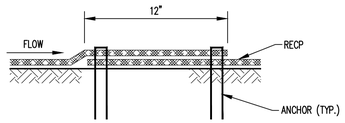
B. OVERLAP AT ADJACENT EDGES



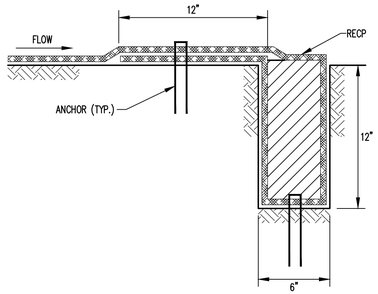
C. UPSTREAM TERMINAL ANCHOR TRENCH



D. INTERMITTENT CHECK SLOT



E. OVERLAP AT ROLL ENDS

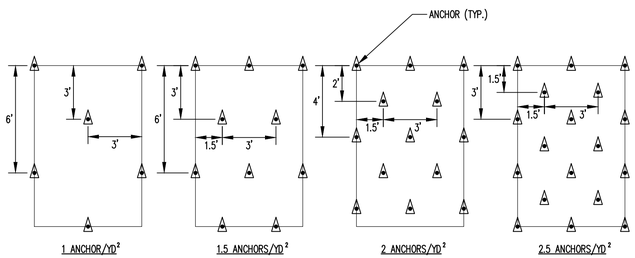


F. DOWNSTREAM TERMINAL ANCHOR TRENCH

NOTES:
1. PLACE ANCHORS AT ANCHOR TRENCHES, OVERLAPS, AND CHECK SLOTS ON 1 FOOT CENTERS. IF APPLICABLE, STAGGER ANCHOR SPACING BETWEEN MULTIPLE ROWS OF ANCHORS.

INSTALLATION OF ROLLED EROSION CONTROL PRODUCTS (CHANNELS)

DETAIL 1 / EC2 — NOT TO SCALE

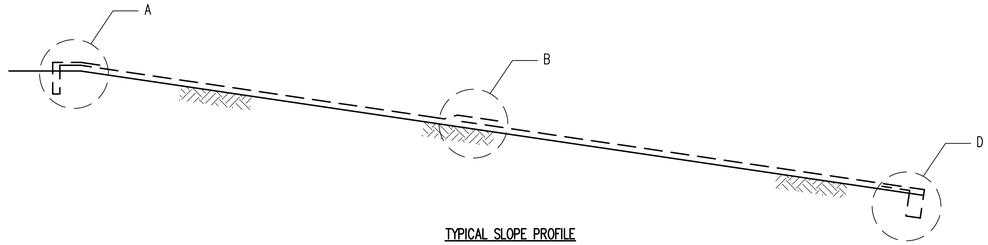


1 ANCHOR/YD² | 1.5 ANCHORS/YD² | 2 ANCHORS/YD² | 2.5 ANCHORS/YD²

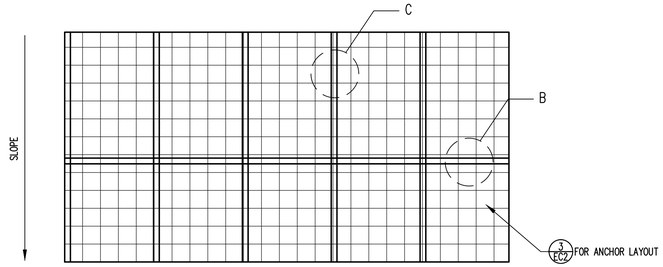
ANCHOR LAYOUT

DETAIL 3 / EC2 — NOT TO SCALE

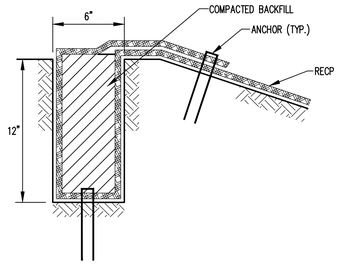
ANCHOR SPACING SCHEDULE	
LOCATION	REQUIRED ANCHOR SPACING (ANCHORS/YD²)
ALL CHANNELS	2.5
1.5H:1V SLOPES	2.0
2H:1V SLOPES	2.0
2.5H:1V SLOPES	1.5
3H:1V SLOPES	1.5
3.5H:1V SLOPES	1.0
4H:1V SLOPES	1.0



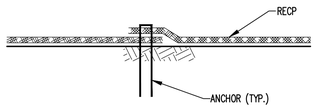
TYPICAL SLOPE PROFILE



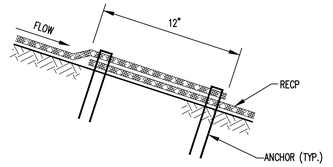
TYPICAL SLOPE PLAN VIEW



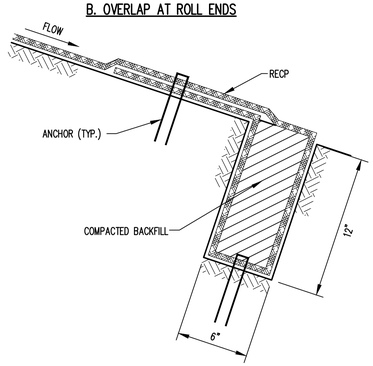
A. UPSLOPE TERMINAL ANCHOR TRENCH



C. OVERLAP AT ADJACENT EDGES



B. OVERLAP AT ROLL ENDS



D. DOWNSLOPE TERMINAL ANCHOR TRENCH

NOTE:
1. PLACE ANCHORS AT ANCHOR TRENCHES, OVERLAPS, AND CHECK SLOTS ON 1 FOOT CENTERS. IF APPLICABLE, STAGGER ANCHOR SPACING BETWEEN MULTIPLE ROWS OF ANCHORS.

INSTALLATION OF ROLLED EROSION CONTROL PRODUCTS (SLOPES)

DETAIL 2 / EC2 — NOT TO SCALE

FOR BIDDING
NOT FOR CONSTRUCTION

SAFETY NOTE:
Contractor shall be solely responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work. Contractor shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection.

PREPARED FOR:

DAVIDSON COUNTY INTEGRATED SOLID WASTE MANAGEMENT LEXINGTON, NORTH CAROLINA

PREPARED BY:

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SEAL

NORTH CAROLINA PROFESSIONAL SEAL 038055 ENGINEER PATRICK K. SCHEIDT
9/29/2016

SEAL

REV.	DATE	DESCRIPTION

PROJECT TITLE:

DAVIDSON COUNTY C&D LANDFILL CLOSURE CONSTRUCTION DRAWINGS

DRAWING TITLE:

EROSION AND SEDIMENTATION CONTROL DETAILS (SHEET 2 OF 2)

DESIGNED: P.K.S.	PROJECT NO: DAVDCO 16-12
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED: PKS	DATE: OCT. 2016
FILENAME: DAVDCO-D0820	
SHEET NUMBER: 7	DRAWING NUMBER: EC2

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