GRADING PLAN
OWL'S DEN LANDFILL
PERMIT NO. 55-02
LINCOLNTON, NORTH CAROLINA

S&ME Project No. 1356-10-028

Prepared for:

North Carolina Department of Environment and Natural Resources
Division of Waste Management – Solid Waste Section
1646 Mail Service Center
Raleigh, North Carolina 27699-1646

Prepared by:

S&ME, Inc.
9751 Southern Pine Blvd
Charlotte, North Carolina 28273

October 1, 2010

October 1, 2010

North Carolina Department of Environment and Natural Resources
Division of Waste Management – Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

Attention: Ms. Jaclynne Drummond
Compliance Hydrogeologist

Reference: **Grading Plan**
Owl's Den Landfill, Permit No. 55-02
Lincolnton, North Carolina
S&ME Project No. 1356-10-028

Dear Ms. Drummond:

S&ME, Inc. (S&ME), on behalf of Lincoln County, submits this Grading Plan for the Owl's Den Landfill. This Grading Plan has been prepared in accordance with the approved Corrective Action Plan for the site, dated July 16, 2010 and approved on August 31, 2010. If you should have any questions or need additional information please contact us at (704)-523-4726.

Respectfully submitted,

S&ME, Inc.

Julie R. Petersen, P.G.
Project Manager/Senior Geologist

Kenneth R. Daly, P.E.
Senior Project Engineer

NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY
10/1/10

Senior reviewed by M. Neal McElveen, P.E., Environmental Services Manager

cc: Nancy Rickard, Lincoln County (1 copy)
Burns Whittaker, Lincoln County (1 copy)

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1. INTRODUCTION

The Owl's Den Landfill (Owl's Den) is owned and formerly operated by Lincoln County. Owl's Den is an unlined landfill that ceased operation in December 1987 and "closed-out" prior to December 1988 with a 24-inch thick soil cover.

In May 2010, NCDENR issued a letter for corrective measures for groundwater, surface water, and methane for which a Corrective Action Plan (CAP) was prepared. S&ME submitted the CAP to NCDENR on July 16, 2010 and was subsequently approved on August 31, 2010. As part of the CAP, S&ME proposed installation of 16 passive gas vents, a 400-foot long passive gas trench, and localized re-grading of the soil cover on site.

Because the results of the aerial survey were not available prior to submittal of the CAP, S&ME provided generalized grading recommendations within the CAP with a stipulation that a Grading Plan would be prepared within 30 days of approval. The following Grading Plan is intended to promote positive drainage of surface water across the site by targeting locally depressed areas which have formed due to differential settlement and to repair or modify existing stormwater control features on site. This Grading Plan is not intended to be a comprehensive re-grading of the entire soil cover.

2. PRE-GRADING ACTIVITIES

The following sections discuss the activities that have occurred or will occur prior to soil cover re-grading.

2.1 Site Clearing and Aerial Survey

To prepare for an aerial survey of the topography of the site, Lincoln County bush-hogged and removed shrubs and trees within the limits of waste. Site clearing was completed on June 30, 2010. Following clearing activities, an aerial survey was flown on July 4, 2010. The aerial survey provided 2-foot contours within the property boundary and provided orthophotography for the site. Data obtained from the aerial survey was used to create the drawings included with this Grading Plan.

2.2 Site Reconnaissance

To aid in the Grading Plan development, S&ME performed a field reconnaissance on September 22, 2010. The purpose of the field reconnaissance was to physically identify features in the field observed from the aerial survey, identify smaller features in the field that were possibly not identified on the aerial survey, locate and assess the condition of existing stormwater control features, and to perform hand auger borings in the central portion of the landfill in an area of suspected non-disposal.

Documentation related to the site reconnaissance, including a field report, hand auger boring logs, site photographs, and a drawing illustrating observed site features and boring locations, is included as ***Appendix I***.

2.3 Installation of Passive Gas Vents and Trench

Prior to re-grading of the site, 16 passive gas vents and 1 passive gas trench will be installed. During the installation process, investigative derived waste (IDW) in the form of excavated soil cover and landfilled waste will be generated. Excavated soil cover may be re-used in the construction of the vents and trench if suitable, as described in the CAP. However, excavated landfilled waste will be stockpiled on plastic adjacent to the excavation to either be re-used to "fill-in" larger depressed areas on-site during re-grading or disposed of at the Lincoln County Landfill.

Because the depth to the bottom of waste is not known, S&ME has estimated an average depth to bottom of waste at 50 feet below land surface. Given 16 passive gas vents, installed to 50 feet below land surface with a 36-inch diameter borehole, S&ME estimates that approximately 209 cubic yards of landfilled waste will be generated from the passive gas vent installation as detailed in the calculations provided in ***Appendix II***.

The passive gas trench will be approximately 400 feet long, 18 inches wide, and 15 feet in depth. Given those dimensions, S&ME estimates that approximately 333 cubic yards of landfilled waste will be generated from the passive gas trench installation as detailed in the calculations provided in ***Appendix II***.

3. LOCATION SPECIFIC GRADING RECOMMENDATIONS

Following review of the July 2010 aerial survey and performing the September 2010 site reconnaissance, S&ME identified four localized areas that will require specific grading. The general areas are depicted on the drawings provided in ***Appendix III*** and include an area of steep grades in the central portion of the landfill (Area 1), poorly drained areas in the north and northwestern portions of the landfill (Area 2), exposed waste in the eastern portion of the landfill (Area 3), and the access road along the southern portion of the landfill (Area 4). Location specific grading recommendations are provided in more detail below.

3.1 Area 1

A localized area of steeply sloping grades was identified in the central portion of the landfill in the vicinity of the suspected "non-disposal" area. As mentioned previously, hand auger borings were performed in this area to evaluate if waste had been placed. Hand auger borings HA-1 through HA-5 were advanced to depths of 3 to 4 feet without encountering waste. However, waste was encountered at an approximate depth of 3 feet within hand auger boring HA-6.

S&ME proposes re-grading this area as detailed in the Drawings in ***Appendix III*** to promote positive drainage across the site and decrease the likelihood of erosion on the slope face. During re-grading of this area, landfilled waste may be encountered. S&ME has provided the following location specific grading recommendations for this area:

- IDW or borrow soils may be used for fill;
- IDW used as fill may only be placed in areas of previous waste disposal;
- if IDW is used as fill, excavate and stockpile topsoil and cover soil in separate

piles in the vicinity of the area to be re-graded. Stockpiled materials should be free of waste and other deleterious materials and may be re-used for soil cover or fill;

- if landfilled waste is encountered in-place in cut areas, material may be used as fill in areas of previous waste disposal or disposed of in the Lincoln County Landfill;
- IDW and/or soil fill should be placed and compacted in maximum 12-inch thick loose lifts to the required general grades as shown on the Drawings in ***Appendix III***;
- at a minimum, two feet of compacted soil cover will be placed over the in-place waste or IDW used as fill;
- soil cover thickness will be verified by hand auger borings if IDW is used as fill as detailed in Section 4; and
- disturbed areas will be seeded as detailed on the drawing provided in ***Appendix III***.

3.2 Area 2

Poorly drained areas currently exist in the northern and northwestern portions of the landfill as depicted on the Drawings in ***Appendix III***. These areas have historically exhibited signs of poor drainage including ponded water. S&ME has proposed drainage improvements at the down slope perimeter of these areas including new drainage pathways and diversions in the perimeter channel.

Due to the localized extent of the poorly draining areas, S&ME has not recommended specific grading plans represented by proposed contours on the drawings. The design intent for these areas is that localized poorly draining areas be filled and graded as a "field fit" to improve drainage. Borrow soils, not IDW, should be used to fill the areas and the areas disturbed should be seeded as detailed on Drawing 3 of 3 provided in ***Appendix III***.

3.3 Area 3

Exposed waste on the eastern portion of the landfill was documented during our site reconnaissance on September 22, 2010. This area is generally shown on the Drawings in ***Appendix III***. Based on our observations, the waste exposed in this area appears to have been uncovered by erosion caused by concentrated stormwater flow. S&ME has provided recommendations to reduce concentrated stormwater flow in this area by modifying the existing rip rap channel as detailed in Section 5.1.2. However, the area of exposed waste will need to be repaired as follows:

- at a minimum, two feet of compacted soil should be placed over the exposed waste such that surface water flow is not impeded in the area;
- waste may be removed to achieve positive drainage;
- soil cover thickness will be verified by hand auger borings as detailed in Section 4; and
- disturbed areas will be seeded as detailed on the drawing provided in ***Appendix III***.

3.4 Area 4

Sections of the access road along the southern portion of the landfill exhibit erosion rills caused by stormwater. A ditch exists on the north side of the access road to the west; however, the ditch diminishes towards the east and stormwater flows over the road causing erosion. S&ME has provided the following location specific grading recommendations for this area:

- remove and stockpile stone surfacing as appropriate. Stockpiled material shall be free of excess dirt and other deleterious material;
- grade road to drain to the south with a maximum 2 percent slope;
- fill in the ditch along the north side of the access road; and
- resurface the road as appropriate with aggregate comparable to existing road surfacing.

4. GENERALIZED GRADING RECOMMENDATIONS

In addition to the location specific recommendations detailed above, S&ME is providing the following general grading recommendations for the identified areas mentioned above (Area 1 through 4). These general grading recommendations also apply to smaller features such as depressions or waste exposures not previously identified which may be encountered during the course of grading activities that will also need to be improved, if discovered.

- Erosion and sediment control (E&SC) measures will need to be implemented as per the approved E&SC Plan. The E&SC Plan is described in more detail in Section 8.
- Fill soils may be obtained on-site from the borrow area. The borrow area is described in more detail in Section 7.
- IDW may be used as fill in areas of previous landfilling only. If IDW is not suitable as fill material then, it must be disposed of at the Lincoln County Landfill.
- Areas should be graded to drain towards existing stormwater conveyance structures and away from the landfill as appropriate.
- Soil placed as fill should be placed in maximum 12 inch lifts and graded to drain towards the landfill perimeter to provide positive drainage.
- If IDW is placed as fill, the following sequence is recommended:
    - Excavate and stockpile topsoil and cover soil in separate piles in the vicinity of the proposed waste placement area. Stockpiled materials should be free of waste and other deleterious material.
    - Place waste in maximum 12-inch lifts and compact as dense as practical.
    - Waste will be covered with a minimum 2 feet of compacted soil cover.
- Following construction, perform hand augers through soil placed over IDW used as fill to verify soil cover thickness. Hand augers should be performed at a minimum frequency of two per acre, but no less than one per discrete IDW fill location.
- Apply topsoil as available. Amend soil with lime and fertilizer as appropriate and

seed according to the seeding specifications on the Drawings in ***Appendix III***.

5. STORMWATER MANAGEMENT SYSTEMS

Drainage across the site will be promoted through the use of existing and new stormwater management systems. The following sections detail both the existing and proposed features for the site.

5.1 Existing Stormwater Control Features

During our site reconnaissance on September 22, 2010, S&ME identified four existing structures that can be used as is, repaired, or modified to promote proper stormwater drainage. The structures identified are described in more detail below and are also depicted on the drawings provided in ***Appendix III***.

5.1.1 Sediment Basin

S&ME identified and visually observed an existing sediment basin located to the north of the landfill adjacent to the edge of waste in a wooded area. S&ME field personnel noted that the riser pipe and outlet pipe visually appeared to be in working condition and were not clogged, the plunge pool was in good condition, and the downstream area appeared stable. Based on our observations, the structure appears usable without modification or repairs.

5.1.2 Rip Rap Channel

A rip rap channel was identified adjacent to the sediment basin extending from within the wooded area and terminating within the waste area. The rip rap channel was observed to be overgrown and in need of repair. Also, it appeared that the rip rap channel was diverting storm water over the waste and eroding the surface cover soils. S&ME recommends cleaning out and repairing the rip rap channel as well as extending the channel and constructing an outlet apron so that stormwater will not erode the surface soils as detailed in ***Appendix III***.

5.1.3 Slope Breaks

Slope breaks consisting of soil berms were observed on the eastern portion of the landfill. The slope breaks appeared washed out and eroded in areas and were generally discontinuous. S&ME recommends either repairing the slope breaks or removing them.

5.1.4 Perimeter Grass-Lined Ditches

The perimeter grass-lined ditches for the landfill appeared to be in working order and providing positive flow of stormwater. However, the lack of outlet structures for the ditches has caused ponding of water in low lying areas. Lack of vegetative growth was also observed in localized areas. S&ME recommends that the channels be re-seeded in areas that are lacking vegetation and that stormwater outlets be installed in low lying areas to divert flow off of the landfill cover. The recommended stormwater outlets are provided in more detail in Section 5.2.2.

5.2 Proposed Stormwater Control Features

S&ME proposes that the following stormwater control features be installed on-site to supplement the existing features in promoting positive stormwater drainage from the landfill cover.

5.2.1 Channel Breaks

To control the stormwater flow within the perimeter grass-lined ditches, S&ME recommends installing periodic channel breaks as detailed in ***Appendix III***. Channel breaks will allow stormwater to discharge off of the landfill face at intermittent locations. Rip rap outlet aprons will be located downstream of channel breaks to decrease flow velocity and depth before discharging to the receiving area.

5.2.2 Rip Rap Outlet Aprons

As mentioned previously, the existing perimeter grass-lined ditches appeared to be in working order; however, they lacked outlets to drain stormwater from the landfill cover. As a consequence of the lack of outlets, stormwater was allowed to pool in low-lying areas creating ponding conditions on the soil cover. To decrease flow velocity and depth discharging from channels, S&ME recommends installing four rip rap outlet aprons at the termination of channel breaks and one rip rap outlet apron at the termination of the rip rap channel as detailed in ***Appendix III***.

6. QUANTITY OF FILL MATERIAL REQUIRED FOR RE-GRADING

Soil and possibly IDW will be used as fill material during re-grading activities. Soil will also be required during construction of the proposed stormwater management structures. S&ME performed calculations to estimate the fill quantities necessary for construction activities so that borrow quantities can be established.

As stated previously, S&ME has estimated that up to 542 cubic yards of IDW may be generated during the installation of the passive gas vents and trench. However, there is a possibility that some, if not all of the IDW will not be suitable for fill or that it may be the contractor's preference not to use the material and haul it to the Lincoln County Landfill.

If IDW is used as fill, S&ME has calculated that the approximately 542 cubic yards of waste available, given compaction and shrinkage factors during placement, would provide an in-place fill quantity of approximately 461 cubic yards as detailed in ***Appendix II***.

Given the recommended areas to be re-graded and the proposed stormwater management features to be constructed, S&ME has estimated that approximately 21,000 cubic yards of fill material (soil and/or IDW) will be necessary to complete the project as detailed in ***Appendix II***. If IDW is not utilized as fill material, the entire quantity will need to be borrow soils.

7. LOCATION AND SIZE OF BORROW AREA

S&ME proposes using the adjacent field to the south of the landfill for borrow soils. The field is owned by Lincoln County, is located on the property, and is easily accessible for grading equipment. The field is approximately 12.9 acres and has adequate topographic relief to provide the estimated soils quantity and provide positive drainage after excavation.

As detailed in the "Fill Demand and Borrow Area" calculation in ***Appendix II***, S&ME anticipates that the soil required for grading activities will require disturbing approximately 4 acres, given the approximate 21,000 cubic yards potentially required to complete the project. Refer to the drawings in ***Appendix III*** for the extents of the proposed borrow area.

S&ME has prepared the following recommendations for the borrow area excavation to decrease the amount of disturbed area and to provide positive stormwater drainage.

- E&SC measures will need to be installed in accordance with the approved E&SC Plan. The E&SC Plan is described in more detail in Section 8.
- The borrow area should be divided into three phases, with each consecutive phase used as it becomes necessary given the amount of IDW that can/will be used. Initiate land disturbance in the northern phase first then activate adjacent phases in steps to the south as required.
- Prior to activation of a phase, excavate and stockpile topsoil.
- During borrow area excavation, grade to drain towards the north and/or west at minimum slopes of 2 percent and maximum slopes of 15 percent in a manner to prevent concentrated flow at the perimeter.
- Following completion of grading activities, replace topsoil as available. Amend soil with lime and fertilizer as appropriate and seed according to the seeding specifications on the Drawings in ***Appendix III***.

8. EROSION AND SEDIMENT CONTROL (E&SC) PLAN

Because more than 1 acre will be disturbed during grading activities, S&ME has prepared and will submit under separate cover an E&SC Plan to the NCDENR Land Quality Section. For the Solid Waste Section's reference, S&ME has provided proposed E&SC control measures on the drawings in ***Appendix III***. A copy of the E&SC Plan can also be provided to the Section if requested.

APPENDIX I

DAILY FIELD REPORT

FIELD PERSONNEL: Courtney Withers & Cedric Ruhl

DATE: September 22, 2010

PROJECT NAME: **OWL'S DEN LANDFILL**
2010 Corrective Action – Phase II

PROJECT NUMBER: 1356-10-028

General Scope
Observe topographic and drainage features at the Owl's Den Landfill for the site grading plan. Perform hand auger borings to approximately 3 to 4 feet below land surface (bls) on historic borrow area mound at the site and note any encountered waste.

Equipment Used
GPS hand-held unit, hand auger, digital camera, measuring wheel.

Detailed Notes
09:30 Courtney Withers (CW) and Cedric Ruhl (CR) of S&ME arrived at the Lincoln County Landfill to pick up keys to the Owl's Den Landfill entrance gate from Mark Bivins of Lincoln County.

09:45 CW and CR arrived at the Owl's Den Landfill and performed site reconnaissance in the southern and western portions of the site via driving a 4x4 pickup truck and walking.

10:15 CW performed hand auger borings on the borrow area mound while CR performed reconnaissance on two low areas at northern and northwestern portions of the landfill. CR observed that a channel and head-cut are forming near monitoring wells MW-4 and MMW-4 at the northwestern end, and that a relatively flat area with few trees extends on the northern tip of the landfill. CW extended hand auger boring 1 (HA-1) to approximately 4 feet bls. Soil encountered in HA-1 from 0 to 4 feet bls was a reddish-brown, micaceous, slightly clayey, silty, fine sand.

10:30 CW extended hand auger boring 2 (HA-2) to approximately 4 feet bls. Soil encountered in HA-2 from 0 to 4 feet bls was a reddish-brown, micaceous, slightly clayey, silty, fine sand.

10:40 CW extended hand auger boring 3 (HA-3) to approximately 4 feet bls. Soil encountered in HA-3 from 0 to 4 feet bls was a reddish-brown, micaceous, slightly clayey, silty, fine sand.

10:50 CW extended hand auger boring 4 (HA-4) to approximately 4 feet bls. Soil encountered in HA-4 from 0 to 4 feet bls was a reddish-brown, micaceous, fine sandy, clayey, silt. CR began recording hand auger boring locations using the GPS.

11:05 CR began hand augering while CW operated the GPS. CR extended hand auger boring 5 (HA-5) to approximately 4 feet bls. Soil encountered in HA-5 from 0 to 4 feet bls was a reddish-brown, micaceous, slightly clayey, silty, fine sand.

11:10 CR extended hand auger boring 6 (HA-6) to approximately 3 feet bls. Soil encountered in HA-6 from 0 to 1.5 feet bls was a yellowish-brown, fine sandy, silt and from 1.5 to 3 feet bls was a reddish-brown, micaceous, slightly clayey, silty, fine sand. Waste was encountered in HA-6 at approximately 3 feet bls. The waste appeared to be a rope or textile of some sort.

11:20 CW and CR performed additional site reconnaissance along the eastern half of the site via pickup truck and walking. The eastern half of the landfill drains north to a riprap channel and east to a diversion berm/channel. The eastern half of the landfill is subdivided by diversion berms which convey stormwater north to the riprap channel. The riprap channel to the north generally follows the treeline eastward and onto the face of the landfill where the riprap becomes sparse to nonexistent. A channel has formed in the cover soils in this area with waste exposed at the surface in some portions of the channel. A hairpin-type bend in the channel re-directs flows to the west toward an existing sediment basin. The sediment basin appears to be functioning properly. The perforated CMP riser does not appear to be clogged, and the outlet CMP pipe and riprap plunge pool appear to be in good, stable condition.

11:45 CW and CR performed site reconnaissance of a field south of the landfill which will be used as a borrow area during implementation of the Grading Plan. The field is currently grassed, gently sloping to a high point roughly near the center of the field.

11:50 CW and CR performed site reconnaissance along the access road along the southern portion of the landfill. An incised ditch was observed near the high point on the road (near the central portion of the southern end of the landfill). As the ditch flows east, it loses shape and spills out over the roadway causing gullies to form on the roadway.

12:00 CW and CR locked the entrance gate to the Owl's Den Landfill and left the site.

12:15 Lunch

13:15 CW and CR arrived at Lincoln County Landfill to drop off Owl's Den Landfill entrance gate key to Mark Bivins.

SUMMARY OF HAND AUGER BORINGS
LINCOLN COUNTY – OWL'S DEN LANDFILL
LINCOLNTON, NORTH CAROLINA
S&ME PROJECT NO. 1356-10-028

DATE	TEST LOCATION	DEPTH (ft bls)	SOIL DESCRIPTION
September 22, 2010	HA-1	0 – 4	**POSSIBLE FILL:** Red-Brown, Micaceous, Slightly Clayey, Silty, Fine Sand Boring terminated at 4 ft bls No water encountered; No waste encountered
	HA-2	0 – 4	**POSSIBLE FILL:** Red-Brown, Micaceous, Slightly Clayey, Silty, Fine Sand Boring terminated at 4 ft bls No water encountered; No waste encountered
	HA-3	0 – 4	**POSSIBLE FILL:** Red-Brown, Micaceous, Slightly Clayey, Silty, Fine Sand Boring terminated at 4 ft bls No water encountered; No waste encountered
	HA-4	0 – 4	**POSSIBLE FILL:** Red-Brown, Micaceous, Fine Sandy, Clayey, Silt Boring terminated at 4 ft bls No water encountered; No waste encountered
	HA-5	0 – 4	**POSSIBLE FILL:** Red-Brown, Micaceous, Slightly Clayey, Silty, Fine Sand Boring terminated at 4 ft bls No water encountered; No waste encountered
	HA-6	0 – 1.5	**FILL:** Yellow-Brown, Fine Sandy, Silt
		1.5 - 3	**FILL:** Red-Brown, Micaceous, Slightly Clayey, Silty, Fine Sand Boring Terminated at 3 ft bls due to encountered waste No water encountered; **Waste encountered at 3 ft bls**

Notes: ft bls = feet below land surface

OWL'S DEN LANDFILL
GRADING PLAN
PHOTOGRAPHS FROM SITE RECON.
S&ME PROJECT NO. 1356-10-028

Photo 1

Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking Southeast
Remarks	View of steeply sloping topography in center of landfill. (Area behind truck)

Photo 2

Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking North
Remarks	Large bowl shaped depression.

OWL'S DEN LANDFILL
GRADING PLAN
PHOTOGRAPHS FROM SITE RECON.
S&ME PROJECT NO. 1356-10-028

Photo 3

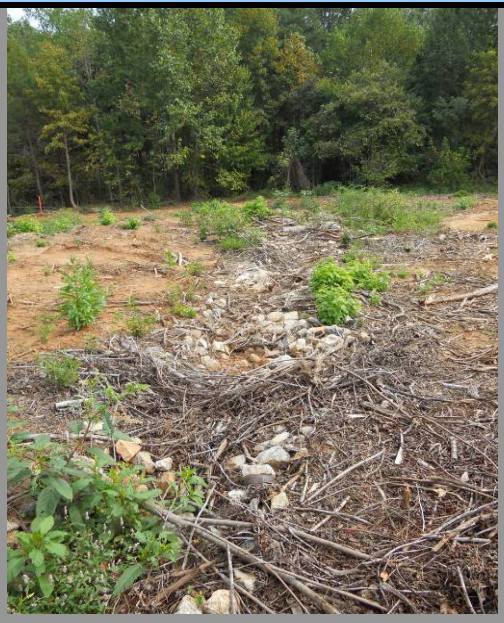
N

Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking Southwest
Remarks	Undulating topography along North slope.

Photo 4



N

Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking East
Remarks	Rip rap channel.

OWL'S DEN LANDFILL
GRADING PLAN
PHOTOGRAPHS FROM SITE RECON.
S&ME PROJECT NO. 1356-10-028

Photo 5

Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking North
Remarks	Sediment basin.

Photo 6

Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking North
Remarks	Sediment basin riser pipe.

OWL'S DEN LANDFILL
GRADING PLAN
PHOTOGRAPHS FROM SITE RECON.
S&ME PROJECT NO. 1356-10-028

Photo 7

Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking South.
Remarks	Sediment basin plunge pool and outlet pipe.

Photo 8

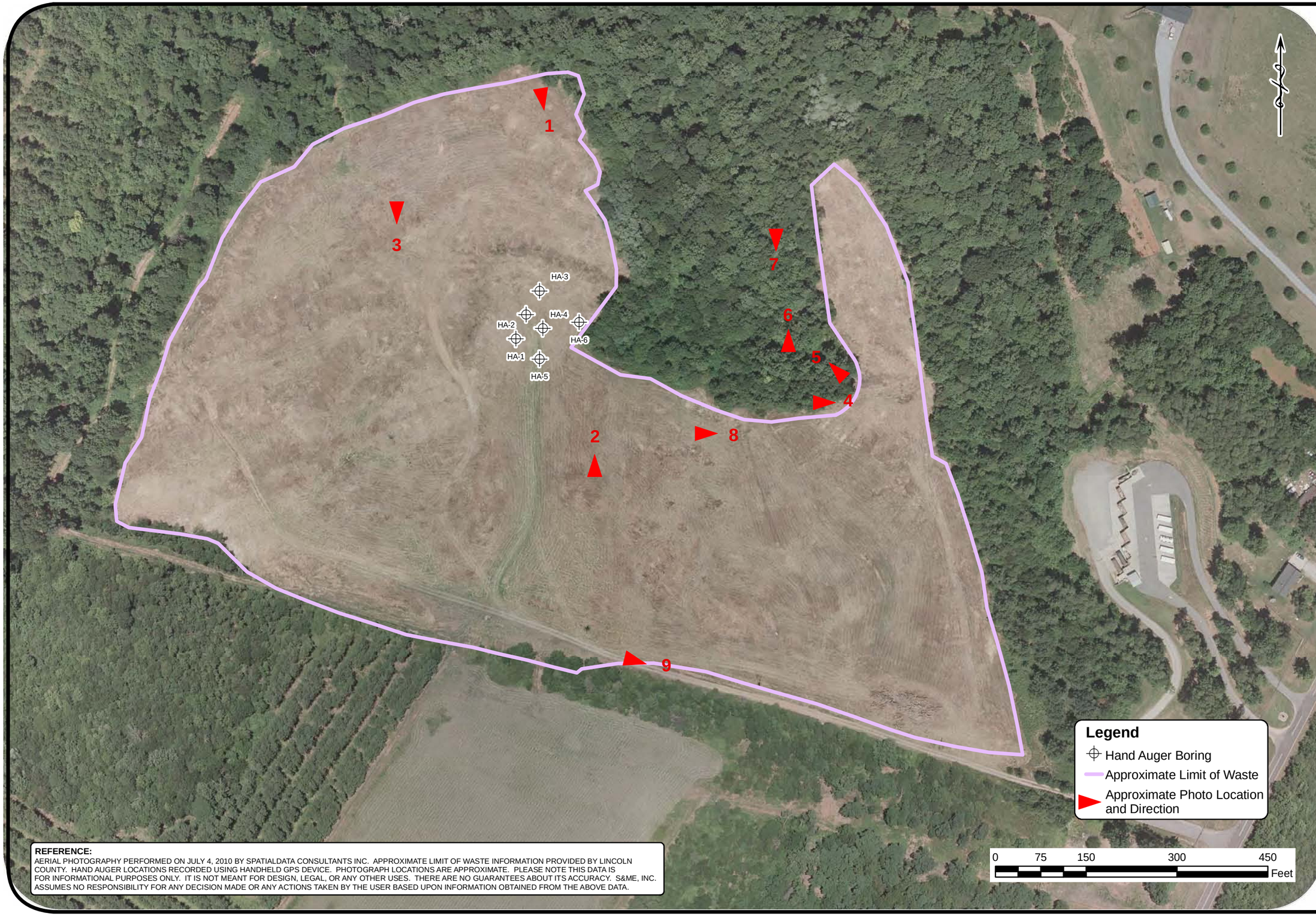
Date: 9/22/2010

Photographer: CW and CR

Location / Orientation	Looking South
Remarks	Slope breaks.

OWL'S DEN LANDFILL
GRADING PLAN
PHOTOGRAPHS FROM SITE RECON.
S&ME PROJECT NO. 1356-10-028

Photo 9		
N	**Date:** 9/22/2010	
	Photographer: CW and CR	
Location / Orientation	Looking East	
Remarks	Access road erosion.	



REFERENCE:
AERIAL PHOTOGRAPHY PERFORMED ON JULY 4, 2010 BY SPATIALDATA CONSULTANTS INC. APPROXIMATE LIMIT OF WASTE INFORMATION PROVIDED BY LINCOLN COUNTY. HAND AUGER LOCATIONS RECORDED USING HANDHELD GPS DEVICE. PHOTOGRAPH LOCATIONS ARE APPROXIMATE. PLEASE NOTE THIS DATA IS FOR INFORMATIONAL PURPOSES ONLY. IT IS NOT MEANT FOR DESIGN, LEGAL, OR ANY OTHER USES. THERE ARE NO GUARANTEES ABOUT ITS ACCURACY. S&ME, INC. ASSUMES NO RESPONSIBILITY FOR ANY DECISION MADE OR ANY ACTIONS TAKEN BY THE USER BASED UPON INFORMATION OBTAINED FROM THE ABOVE DATA.

DATE:	09-30-10
DRAWN BY:	CHR
CHECKED BY:	JP
SCALE:	1" = 150'
PROJECT NO:	1356-10-028

S&ME
WWW.SMEINC.COM

VICINITY MAP
SEPTEMBER 22, 2010 SITE VISIT

GRADING PLAN - OWL'S DEN LANDFILL
LINCOLN COUNTY, NORTH CAROLINA

FIGURE NO.

1

APPENDIX II

S&ME

PROJECT NO. 1356-10-028

SHEET NO. 1 / 4

DATE September 29, 2010

JOB NAME Lincoln County – Owl's Den Landfill 2010 Corrective Action

COMPUTED BY CHR

SUBJECT Fill Demand and Borrow Area

CHECKED BY

COMPUTATIONS BY:

Signature Cedric Ruhl KD

Date 10/1/10

Name Cedric Ruhl, P.E.

Title Project Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Julie R. Petersen

Date 10/1/10

Name Julie Petersen, P.G.

Title Senior Project Geologist

COMPUTATIONS CHECKED BY:

Signature Julie R. Petersen

Date 10/1/10

Name Julie Petersen, P.G.

Title Senior Project Geologist

REVIEWED BY:

Signature Kenneth R. Daly

Date 10/1/10

Name Kenneth Daly, P.E.

Title Senior Project Engineer

REVIEW NOTES / COMMENTS:

S&ME

PROJECT NO. 1356-10-028
SHEET NO. 2 / 4
DATE September 29, 2010
JOB NAME Lincoln County – Owl's Den Landfill 2010 Corrective Action
COMPUTED BY CHR
SUBJECT Fill Demand and Borrow Area
CHECKED BY

OBJECTIVE:

The objective of this calculation is to provide a ball park estimate of the gross quantity of fill which will be required for miscellaneous grading activities at the Owl's Den landfill, and to estimate the required surface area of the borrow source.

METHOD:

Fill demand will be estimated by making assumptions on the quantity of fill required to provide positive drainage at the Owl's Den landfill facility with a factor of 2 for potentially unanticipated soil demand. Fill supply will come in part from material excavated during gas cutoff trench and gas vent excavations, and in part from a borrow area adjacent to the landfill, and will include a shrinkage factor of 15 percent. S&ME assumes that at least 2 feet of soil cover will be constructed over any waste placed as fill, and any waste currently exposed.

CALCULATIONS:

1. Estimate borrow demand.

S&ME assumes that Lincoln County will fill in low areas at the Owl's Den landfill to provide positive stormwater drainage, and will cover waste with at least 2 feet of soil cover. S&ME has included a factor of 2 for potentially unanticipated soil demand. Fill demand is categorized and estimated amounts quantified in the following table:

TABLE 1: FILL DEMAND

Description	Surface Area (ft^2)	Average Depth (ft)	Gross Volume (ft^3)	Gross Volume (yd^3)	Factor	Estimated Volume (yd^3)
Mass Grading - Low Areas	40,000	2	80,000	2,963	2	5,926
Mass Grading - Knoll Area	-	-	-	5,100	1	5,100
Localized Grading - Low Areas	50,000	1	50,000	1,852	2	3,704
Grading Over Waste	10,000	2	20,000	741	2	1,481
Misc. Items (stormwater, etc.)	-	-	-	1,000	2	2,000
					TOTAL	18,211

2. Estimate fill supply from gas management structures.

S&ME understands that fill supply will come from excavated material during construction of gas vents and a gas cutoff trench, as well as an adjacent borrow area. S&ME has estimated the fill supply from construction of gas management structures, assuming a 15 percent shrinkage factor, as shown in the following table:

TABLE 2: FILL SUPPLY - GAS MANAGEMENT STRUCTURES

Description	Length (ft)	Width or Diameter (ft)	Depth (ft)	Quantity (ft)	Volume (ft^3)	Volume (yd^3)	Shrinkage Factor	Net Volume (yd^3)
Gas Vents	0	3	50	16	5,655	209	15%	178
Gas Cutoff Trench	400	2	15	1	9,000	333	15%	283
							TOTAL	461

SRP

3. Estimate required fill from adjacent borrow area.

The difference in quantities calculated in steps 1 and 2 will be required from the borrow area, as shown in the following table:

TABLE 3: BORROW AREA

Fill Demand (yd^3)	Fill Supply from Gas Mgmt. Structures (yd^3)	Volume Required from Borrow Area (yd^3)	Shrinkage Factor	Net Volume (yd^3)	Average Depth of Borrow Area (ft)	Required Area of Borrow (ft^2)	Required Area of Borrow (ac)
18,211	461	17,750	15%	20,412	3.0	183,710	4.22

SRP

DISCUSSION:

S&ME has assumed a factor of 2 for fill demand, and a shrinkage factor of 15 percent for fill supply. These factors have been included due to:

- Unknown number, size, and configuration of areas requiring fill to provide positive stormwater drainage;
- Unknown volume of fill required to construct and restore stormwater management structures;
- Unknown area where waste is currently or may potentially be exposed; and
- Unknown depth of fill available from the borrow area.

CONCLUSIONS:

The estimated gross fill demand is approximately 21,000 cubic yards, the estimated borrow area should be approximately 4 acres.

S&ME

PROJECT NO. 1356-10-028

SHEET NO. 1 / 6

DATE October 01, 2010

JOB NAME Lincoln County – Owl's Den Landfill 2010 Corrective Action

COMPUTED BY CHR

SUBJECT Riprap Channel

CHECKED BY MAH

COMPUTATIONS BY:

Signature Cedric Ruhl (CRH) Date 10/01/2010

Name Cedric Ruhl, P.E.

Title Project Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Date 10/01/2010

Name Joshua M. Bell, P.E.

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature Date 10/01/2010

Name William M. Harrison, E.I.

Title Staff Professional

REVIEWED BY:

Signature Date 10/1/10

Name Kenneth R. Daly, P.E.

Title Senior Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

The objective of this calculation is to estimate stability of the proposed improvements to the riprap channel for sub-drainage area SDA-3.

METHOD:

The permissible shear stress method will be used to estimate stability of the riprap channel.

SUMMARY:

The riprap channel should be constructed to the following dimensions and underlain with an 8 oz/sy nonwoven geotextile:

SUMMARY					
Sub-Drainage Area	Median Stone Size {D_{50}} (in)	Maximum Stone Size {D_{max}} (in)	Riprap Thickness (in)	Bottom Width {B} (ft)	Side Slopes {ZH:1V}
SDA-3	6	9	14	2	2

CALCULATIONS:

1. Define riprap channel dimensions.

Sub-drainage area SDA-3 is generally bounded by a riprap channel to the north. Drainage across SDA-3 is generally directed to the riprap channel via several soil berms. The existing riprap channel will be extended and improved to match the dimensions described in this calculation. Riprap channel dimensions are described in the following table:

TABLE 1: CHANNEL DIMENSIONS						
Sub-Drainage Area	Median Stone Size {D_{50}} (in)	Maximum Stone Size {D_{max}} (in)	Riprap Thickness (in)	Bottom Width {B} (ft)	Side Slopes {ZH:1V}	Channel Slope {S} (ft/ft)
SDA-3	6	9	14	2	2	0.0559

2. Calculate normal flow depth.

Flow for sub-drainage area SDA-3 during the 25-year event was calculated in the companion "Runoff" calculation. The normal flow depth within the riprap channel for the 25-year event was estimated by using Manning's equation as described in Reference 1 and presented in the relationships below:

$Q = AV$ and

$$V = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Where:

Q = channel flow (cfs);

A = flow area within the channel (square feet);

V = velocity of flow within the channel (feet per second).

n = Manning's roughness coefficient (dimensionless);

R = hydraulic radius of flow within the channel (feet); and

S = slope of the channel (feet per foot).

For trapezoidal channels:

$A = bd + Zd^2$ and

$$R = \frac{A}{b + 2d\sqrt{Z^2 + 1}}$$

Where:

A = flow area within the channel (square feet);

b = base width of the channel (feet);

d = normal depth of flow within the channel (feet);

Z = side slope of channel (ZH/1V) (dimensionless); and

R = hydraulic radius of flow within the channel (feet).

The normal depth of flow was iteratively adjusted until the calculated flow rate within the channel was close to, but greater than, the calculated flow rate from the 25-year storm event.

TABLE 2: NORMAL DEPTH							
Sub-Drainage Area	Flow from 25-Year Storm {Q_{25}} (cfs)	Slope {S} (ft/ft)	Manning's n {n} [Ref. 1]	Flow Area {A} (sq ft)	Hydraulic Radius {R} (ft)	Calculated Flow {Q} (cfs)	Normal Depth of Flow {d} (ft)
SDA-3	3.24	0.0559	0.069	1.50	0.35	3.83	0.5

3. Calculate shear stress in channel.

Shear stress within the channel is calculated as described in Reference 1 and as presented below:

$T = yds$

Where:

T = shear stress (psf);

y = unit weight of water (62.4 pcf);

d = normal depth of flow within the channel (feet); and

s = slope of the channel (feet per foot).

TABLE 3: CALCULATED SHEAR STRESS				
Sub-Drainage Area	Unit Weight of Water {y} (pcf)	Normal Depth of Flow {d} (ft)	Channel Slope {S} (ft/ft)	Calculated Shear Stress {T} (psf)
SDA-3	62.40	0.5000	0.0559	1.74

4. Evaluate stability of riprap channel.

The allowable shear stress in the channel is presented in Reference 1 and stability is checked in the following table:

TABLE 4: RIPRAP CHANNEL STABILITY				
Sub-Drainage Area	Median Stone Size {D_{50}} (in)	Allowable Shear Stress {T} (psf)	Calculated Shear Stress {T} (psf)	Stability Check
SDA-3	6	2.00	1.74	STABLE

DISCUSSION:

A riprap channel should be installed in the location and to the dimensions shown on the drawings. Riprap channel installation may require modifying the existing riprap channel. Existing soil berms should be either raised and improved to direct flows to the riprap ditch, or smoothed to prevent concentrated flows from flowing over the face of the landfill.

CONCLUSIONS:

The riprap channel should be constructed to the following dimensions and underlain with an 8 oz/sy nonwoven geotextile:

SUMMARY					
Sub-Drainage Area	Median Stone Size {D_{50}} (in)	Maximum Stone Size {D_{max}} (in)	Riprap Thickness (in)	Bottom Width {B} (ft)	Side Slopes {ZH:1V}
SDA-3	6	9	14	2	2

REFERENCES:

1. "Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.

REFERENCE 1

"Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.

The permissible velocity procedure is recommended for the design of vegetative channels because of common usage and the availability of reliable design tables. The tractive force approach is recommended for design of channels with temporary synthetic liners or riprap liners. The tractive force procedure is described in full in the U.S. Department of Transportation, Federal Highway Administration Bulletin, *Design of Roadside Channels with Flexible Linings*.

Permissible Velocity Procedure

The permissible velocity procedure uses two equations to calculate flow:

Manning's equation,

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where:

V	=	average velocity in the channel in ft/sec.
n	=	Manning's roughness coefficient, based upon the lining of the channel
R	=	hydraulic radius, wetted cross-sectional area/wetted perimeter in ft
S	=	slope of the channel in ft/ft

and the continuity equation,

$$Q = AV$$

where:

Q	=	flow in the channel in cfs
A	=	cross-sectional area of flow within the channel in ft^2
V	=	average velocity in the channel in ft/sec.

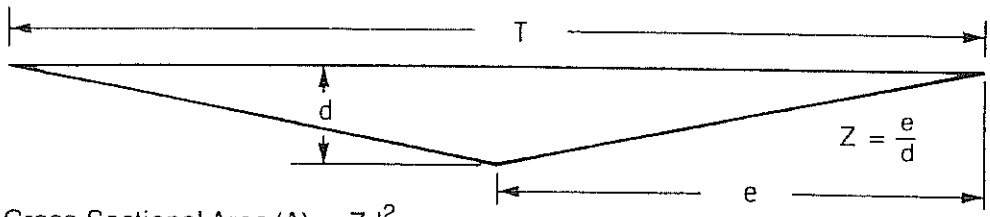
Manning's equation and the continuity equation are used together to determine channel capacity and flow velocity. A nomograph for solving Manning's equation is given in Figure 8.05a.

Selecting Permanent Channel Lining

Channel lining materials include such flexible materials as grass, riprap and gabions, as well as rigid materials such as paving blocks, flag stone, gunite, asphalt, and concrete. The design of concrete and similar rigid linings is generally not restricted by flow velocities. However, flexible channel linings do have maximum permissible flow velocities beyond which they are susceptible to erosion. The designer should select the type of liner that best fits site conditions.

Table 8.05a lists maximum permissible velocities for established grass linings and soil conditions. Before grass is established, permissible velocity is determined by the choice of temporary liner. Permissible velocities for riprap linings are higher than for grass and depend on the stone size selected.

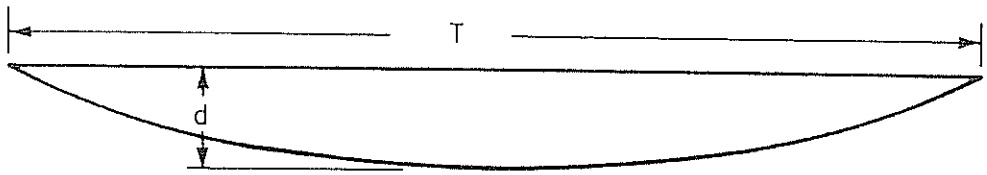
V-Shape



Cross-Sectional Area (A) = Zd^2
Top Width (T) = $2dZ$

$$\text{Hydraulic Radius (R)} = \frac{Zd}{2\sqrt{Z^2 + 1}}$$

Parabolic Shape

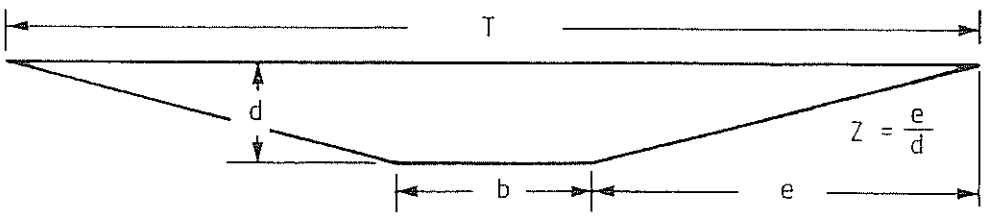


$$\text{Cross-Sectional Area (A)} = \frac{2}{3}\,Td$$

$$\text{Top Width (T)} = \frac{1.5\,A}{d}$$

$$\text{Hydraulic Radius} = \frac{T^2 d}{1.5T^2 + 4d^2}$$

Trapezoidal Shape



Cross-Sectional Area (A) = $bd + Zd^2$
Top Width (T) = $b + 2dZ$

$$\text{Hydraulic Radius} = \frac{bd + Zd^2}{b + 2d\sqrt{Z^2 + 1}}$$

Figure 8.05b Channel geometries for v-shaped, parabolic and trapezoidal channels.

Table 8.05f Manning's Roughness Coefficient

Lining Category	Lining Type	*n* - value: *n* value for Depth Ranges 0-0.5 ft (0-15 cm)	0.5-2.0 ft (15-60 cm)	2.0 ft (>60 cm)
Rigid	Concrete	0.015	0.013	0.013
	Grouted Riprap	0.040	0.030	0.028
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil	0.023	0.020	0.020
	Rock Cut	0.045	0.035	0.025
Gravel Riprap	1-inch (2.5-cm) D_{50}	0.044	0.033	0.030
	2-inch (5-cm) D_{50}	0.066	0.041	0.034
Rock Riprap	6-inch (15-cm) D_{50}	0.104	0.069	0.035
	12-inch (30-cm) D_{50}	--	0.078	0.040

Note: Values listed are representative values for the respective depth ranges. Manning's roughness coefficients, *n*, vary with the flow depth.

DETERMINING SHEAR STRESS

Shear stress, T, at normal depth is computed for the lining by the following equation:

$$T = yds$$

$$T_d = \text{Permissible shear stress}$$

where:

T = shear stress in lb/ft^2
y = unit weight of water, 62.4 lb/ft^3
d = flow depth in ft
s = channel gradient in ft/ft

If the permissible shear stress, T_d, given in Table 8.05g is greater than the computed shear stress, the riprap or temporary lining is considered acceptable. If a lining is unacceptable, select a lining with a higher permissible shear stress and repeat the calculations for normal depth and shear stress. In some cases it may be necessary to alter channel dimensions to reduce the shear stress.

Computing tractive force around a channel bend requires special considerations because the change in flow direction imposes higher shear stress on the channel bottom and banks. The maximum shear stress in a bend, T_b, is given by the following equation:

$$T_b = K_b T$$

where:

T_b = bend shear stress in lb/ft^2
k_b = bend factor
T = computed stress for straight channel in lb/ft^2

The value of k_b is related to the radius of curvature of the channel at its center line, R_c, and the bottom width of the channel, B, Figure 8.05e. The length of channel requiring protection downstream from a bend, L_p, is a function of the roughness of the lining material and the hydraulic radius as shown in Figure 8.05f.

Table 8.05g
Permissible Shear Stresses for Riprap and Temporary Liners

Lining Category	Permissible Unit Shear Stress, T_d Lining Type	(lb/ft^2)
Temporary	Woven Paper Net	0.15
	Jute Net	0.45
	Fiberglass Roving:	
	Single	0.60
	Double	0.85
	Straw with Net	1.45
	Curled Wood mat	1.55
	Synthetic Mat	2.00
	d_{50} **Stone Size** (inches)	
Gravel Riprap	1	0.33
	2	0.67
Rock Riprap	6	2.00
	9	3.00
	12	4.00
	15	5.00
	18	6.00
	21	7.80
	24	8.00

Adapted From: FHWA, HEC-15, April 1983, pgs. 17 & 37.

Design Procedure-Temporary Liners

The following is a step-by-step procedure for designing a temporary liner for a channel. Because temporary liners have a short period of service, the design Q may be reduced. For liners that are needed for six months or less, the 2-year frequency storm is recommended.

Step 1. Select a liner material suitable for site conditions and application. Determine roughness coefficient from manufacturer's specifications or Table 8.05e, page 8.05.10.

Step 2. Calculate the normal flow depth using Manning's equation (Figure 8.05d). Check to see that depth is consistent with that assumed for selection of Manning's *n* in Figure 8.05d, page 8.05.11. For smaller runoffs Figure 8.05d is not as clearly defined. Recommended solutions can be determined by using the Manning equation.

Step 3. Calculate shear stress at normal depth.

Step 4. Compare computed shear stress with the permissible shear stress for the liner.

Step 5. If computed shear is greater than permissible shear, adjust channel dimensions to reduce shear, or select a more resistant lining and repeat steps 1 through 4.

Design of a channel with temporary lining is illustrated in Sample Problem 8.05b, page 8.05.14.

S&ME

PROJECT NO. 1356-10-028

SHEET NO. 1 / 4

DATE October 01, 2010

JOB NAME Lincoln County – Owl's Den Landfill 2010 Corrective Action

COMPUTED BY CHR

SUBJECT Riprap Apron

CHECKED BY

COMPUTATIONS BY:

Signature Cedric Ruhl (rmd) Date 10/01/2010

Name Cedric Ruhl, P.E.

Title Project Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature Date 10/01/2010

Name Joshua M. Bell, P.E.

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature Date 10/01/2010

Name William M. Harrison, E.I.

Title Staff Professional

REVIEWED BY:

Signature Date 10/1/10

Name Kenneth R. Daly, P.E.

Title Senior Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

The objective of this calculation is to design a riprap apron to be located at the termination of the riprap channel.

METHOD:

The riprap apron will be designed in general accordance with the North Carolina Department of Environment and Natural Resource's (NCDENR) "Erosion and Sediment Control Planning and Design Manual".

SUMMARY:

The riprap apron should be constructed to the following dimensions and underlain with an 8 oz/sy nonwoven geotextile:

SUMMARY					
Selected Median Stone Size {d_{50}} (in)	Maximum Stone Size {d_{max}} (in)	Apron Thickness (in)	Apron Length {L_a} (ft) [Ref. 1]	Upstream Apron Width {3Do} (ft) [Ref. 1]	Downstream Apron Width {W} (ft) [Ref. 1]
6	9	13.5	6	4.5	10.5

CALCULATIONS:

1. Describe outlet flow to riprap apron.

The riprap apron will receive flow from the riprap channel as described in the companion calculation package "Riprap Channel". The flow area from the riprap apron was converted into an equivalent pipe diameter as shown in the following table:

TABLE 1: FLOW FROM RIPRAP CHANNEL		
Flow from 25-Year Storm {Q_{25}} (cfs)	Flow Area {A} (sq ft)	Equivalent Pipe Diameter {Do} (in)
3.24	1.50	16.58

2. Calculate riprap apron dimensions.

Riprap apron dimensions were sized based on calculations and tables presented in NCDENR's "Erosion and Sediment Control Planning and Design Manual" (Reference 1) and summarized in the following table:

TABLE 2: RIPRAP APRON SIZE								
Flow from 25-Year Storm {Q_{25}} (cfs)	Equivalent Pipe Diameter {Do} (in)	Calculated Median Stone Size {d_{50}} (ft) [Ref. 1]	Selected Median Stone Size {d_{50}} (in)	Maximum Stone Size {d_{max}} (in)	Apron Thickness (in)	Apron Length {L_a} (ft) [Ref. 1]	Upstream Apron Width {3Do} (ft) [Ref. 1]	Downstream Apron Width {W} (ft) [Ref. 1]
3.24	16.58	0.2	6	9	13.5	6	4.5	10.5

DISCUSSION:

The riprap apron should be installed at the outlet of the riprap channel.

CONCLUSIONS:

The riprap apron should be constructed to the following dimensions and underlain with an 8 oz/sy nonwoven geotextile:

SUMMARY					
Selected Median Stone Size {d_{50}} (in)	Maximum Stone Size {d_{max}} (in)	Apron Thickness (in)	Apron Length {L_a} (ft) [Ref. 1]	Upstream Apron Width {3Do} (ft) [Ref. 1]	Downstream Apron Width {W} (ft) [Ref. 1]
6	9	13.5	6	4.5	10.5

REFERENCES:

1. "Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.

REFERENCE 1

"Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.

8.06

DESIGN OF RIPRAP OUTLET PROTECTION

Riprap (large stones of various sizes) is often used to prevent erosion at the ends of culverts and other pipe conduits. It converts high-velocity, concentrated pipe flow into low-velocity, open channel flow. Stone should be sized and the apron shaped to protect receiving channels from erosion caused by maximum pipe exit velocities. Riprap outlet structures should meet all requirements in *Practice Standards and Specifications: 6.41, Outlet Stabilization Structure.*

Several methods are available for designing riprap outlet structures. The method presented in this section is adapted from procedures used by the USDA Soil Conservation Service. Outlet protection is provided by a level apron of sufficient length and flare to reduce flow velocities to nonerosive levels.

Design Procedure for Riprap Outlet Protection

The following procedure uses two sets of design curves: Figure 8.06a is used for minimum tailwater conditions, and Figure 8.06b for maximum tailwater conditions.

Step 1. Determine the tailwater depth from channel characteristics below the pipe outlet for the design capacity of the pipe. If the tailwater depth is less than half the outlet pipe diameter, it is classified minimum tailwater condition. If it is greater than half the pipe diameter, it is classified maximum condition. Pipes that outlet onto wide flat areas with no defined channel are assumed to have a minimum tailwater condition unless reliable flood stage elevations show otherwise.

Step 2. Based on the tailwater conditions determined in step 1, enter Figure 8.06a or Figure 8.06b, and determine d_{50} riprap size and minimum apron length (L_a). The d_{50} size is the median stone size in a well-graded riprap apron.

Step 3. Determine apron width at the pipe outlet, the apron shape, and the apron width at the outlet end from the same figure used in Step 2.

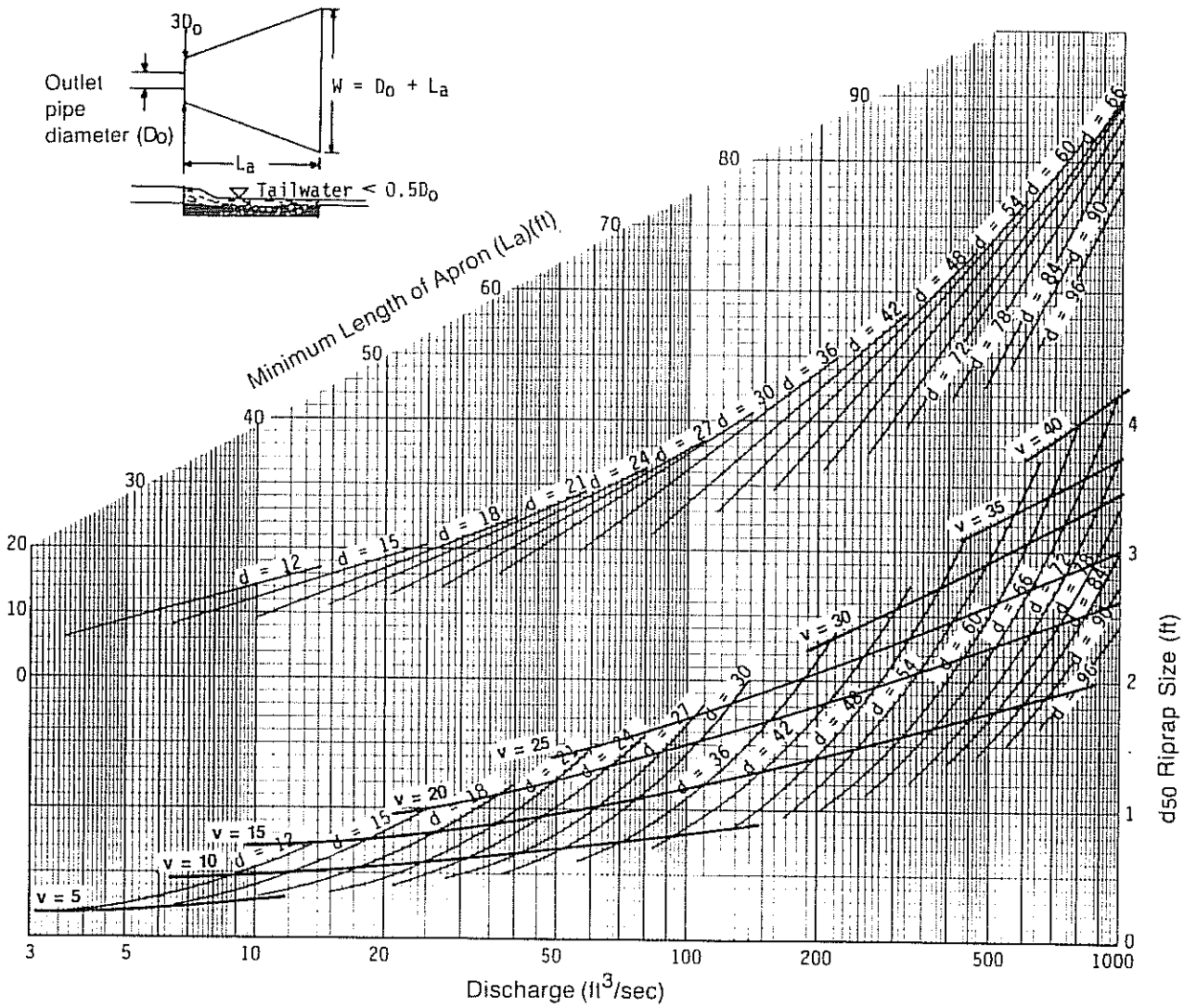
Step 4. Determine the maximum stone diameter:

$$d_{max} = 1.5 \times d_{50}$$

Step 5. Determine the apron thickness:

$$\text{Apron thickness} = 1.5 \times d_{max}$$

Step 6. Fit the riprap apron to the site by making it level for the minimum length, L_a, from Figure 8.06a or Figure 8.06b. Extend the apron farther downstream and along channel banks until stability is assured. Keep the apron as straight as possible and align it with the flow of the receiving stream. Make any necessary alignment bends near the pipe outlet so that the entrance into the receiving stream is straight.



Curves may not be extrapolated.

Figure 8.06a Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).

S&ME

PROJECT NO. 1356-10-028

SHEET NO. 1 / 7

DATE October 01, 2010

JOB NAME Lincoln County – Owl's Den Landfill 2010 Corrective Action

COMPUTED BY CHR

SUBJECT Runoff

CHECKED BY

COMPUTATIONS BY:

Signature Cedric Ruhl (CRR)

Date 10/01/2010

Name Cedric Ruhl, P.E.

Title Project Engineer

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Date 10/08/2010

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Date 10/01/2010

Name William M. Harrison, E.I.

Title Staff Professional

REVIEWED BY:

Signature

Date 10/1/10

Name Kenneth R. Daly, P.E.

Title Senior Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

The objective of this calculation is to calculate runoff to the sub-drainage areas within the Owl's Den landfill.

METHOD:

Runoff will be calculated for the 25-year storm event using the Rational Method.

SUMMARY:

Calculated flow rates for the 25-year storm event are summarized in the following table:

SUMMARY	
Sub-Drainage Area	Flow $\{Q_{25}\}$ (cfs)
SDA-1	3.87
SDA-2	1.05
SDA-3	3.24

CALCULATIONS:

1. Define sub-drainage areas.

The Owl's Den landfill can generally be divided into three sub-drainage areas as shown on the figure in Reference 1. Sub-drainage area characteristics are summarized in the following table, assuming long-term stabilized vegetative conditions:

TABLE 1: SUB-DRAINAGE AREA CHARACTERISTICS				
Sub-Drainage Area [Ref. 1]	Area {A} (ft^2) [Ref. 1]	Area {A} (ac)	Drainage Length {L} (ft) [Ref. 1]	Surface Description
SDA-1	421,057	9.67	1,330	pasture, sandy soils
SDA-2	114,868	2.64	1,015	pasture, sandy soils
SDA-3	352,997	8.10	1,361	pasture, sandy soils

2. Calculate travel time due to sheet flow.

The travel time due to sheet flow is calculated using the Kinematic Wave Theory as described in Reference 2 and presented as follows:

$$T_c = \frac{\left[\dfrac{L}{\alpha\left(I_i C / 43{,}200\right)^{2/3}}\right]^{3/5}}{60 \text{ min}}$$

Where:

T_c = travel time due to sheet flow (minutes);

L = length of overland flow (feet), assumed to be 100 feet;

I_i = rainfall intensity (inches per hour);

C = rational runoff coefficient (dimensionless); and

$$\alpha = \frac{1.49 S^{0.5}}{n}$$

Where:

S = slope (feet/foot); and

n = Manning's roughness coefficient (dimensionless).

Rainfall intensities for different 25-year storm durations were tried iteratively until the calculated travel time was close to, but greater than, the travel time for the corresponding rainfall intensity. The travel time for the sub-drainage areas are calculated as follows:

TABLE 2: TRAVEL TIME DUE TO SHEET FLOW							
Sub-Drainage Area	Slope {S} (ft/ft) [Ref. 1]	Manning's n {n} [Ref. 2]	Alpha {α}	Flow Length {L} (ft)	Rainfall Intensity $\{I_{i,25}\}$ (in/hr) [Ref. 2]	Runoff Coefficient {C} [Ref. 2]	Travel Time Due to Sheet Flow $\{T_{c,sheet}\}$ (minutes)
SDA-1	0.0050	0.240	0.44	100	4.00	0.10	44.6
SDA-2	0.0050	0.240	0.44	100	4.00	0.10	44.6
SDA-3	0.0190	0.240	0.86	100	4.00	0.10	29.9

3. Calculate travel time due to shallow concentrated flow.

The travel time due to shallow concentrated flow is calculated using the FHWA and NRCS method as described in Reference 2 and presented as follows (assuming unpaved conditions):

$$T = \frac{L}{60V} \text{ and}$$

$$V = 16.1345S^{1/2}$$

Where:

T = travel time due to shallow concentrated flow (minutes);

L = flow length (feet);

V = flow velocity (feet per second); and

S = slope (feet/foot).

The flow length due to shallow concentrated flow was calculated by subtracting the flow length due to sheet flow from the total flow length presented in Table 1. Travel time due to shallow concentrated flow is calculated as presented in the following table:

TABLE 3: TRAVEL TIME DUE TO SHALLOW CONCENTRATED FLOW				
Sub-Drainage Area	Slope {S} (ft/ft) [Ref. 1]	Velocity {V} (ft/s)	Flow Length {L} (ft)	Travel Time Due to SCF $\{T_{c,scf}\}$ (minutes)
SDA-1	0.0539	3.74	1,230	5.5
SDA-2	0.0658	4.14	915	3.7
SDA-3	0.0559	3.81	1,261	5.5

4. Calculate total travel time.

The total travel time for each sub-drainage area is calculated by adding the travel times for the flow regimes calculated above. The calculated travel time and travel time used to select rainfall intensity is presented in the following table:

TABLE 4: TOTAL TRAVEL TIME			
Sub-Drainage Area	Total Calculated Travel Time {T_c} (minutes)	Total Travel Time for Rainfall Intensity {T_c} (minutes)	Rainfall Intensity {$I_{1,25}$} (in/hr) [Ref. 2]
SDA-1	50.1	30	4.00
SDA-2	48.3	30	4.00
SDA-3	35.4	30	4.00

5. Calculate flow for the 25-year storm event.

Flow for the 25-year storm event was calculated using the Rational Method as described in Reference 2 and shown as follows:

$Q = CIA$

Where:

Q = flow rate (cfs);

C = rational runoff coefficient (dimensionless);

I = rainfall intensity (inches per hour); and

A = drainage area (acres).

The runoff for the 25-year storm event is calculated as shown in the following table:

TABLE 5: PEAK FLOW				
Sub-Drainage Area	Runoff Coefficient {C}	Rainfall Intensity {$I_{i,25}$} (in/hr) [Ref. 2]	Area {A} (ac)	Flow {Q_{25}} (cfs)
SDA-1	0.10	4.00	9.67	3.87
SDA-2	0.10	4.00	2.64	1.05
SDA-3	0.10	4.00	8.10	3.24

DISCUSSION:

The following levels of conservatism were introduced into this calculation:

- Stormwater structures are typically sized to pass the 10-year storm event; however, for this calculation peak runoff was calculated for the 25-year storm event.
- The total travel time was calculated to be within 35 and 50 minutes; however, a travel time of 30 minutes was assumed.

For the purposes of this calculation, it was assumed that the contributing drainage area would be seeded, and that a good ground cover would be maintained.

CONCLUSIONS:

Calculated flow rates for the 25-year storm event are summarized in the following table:

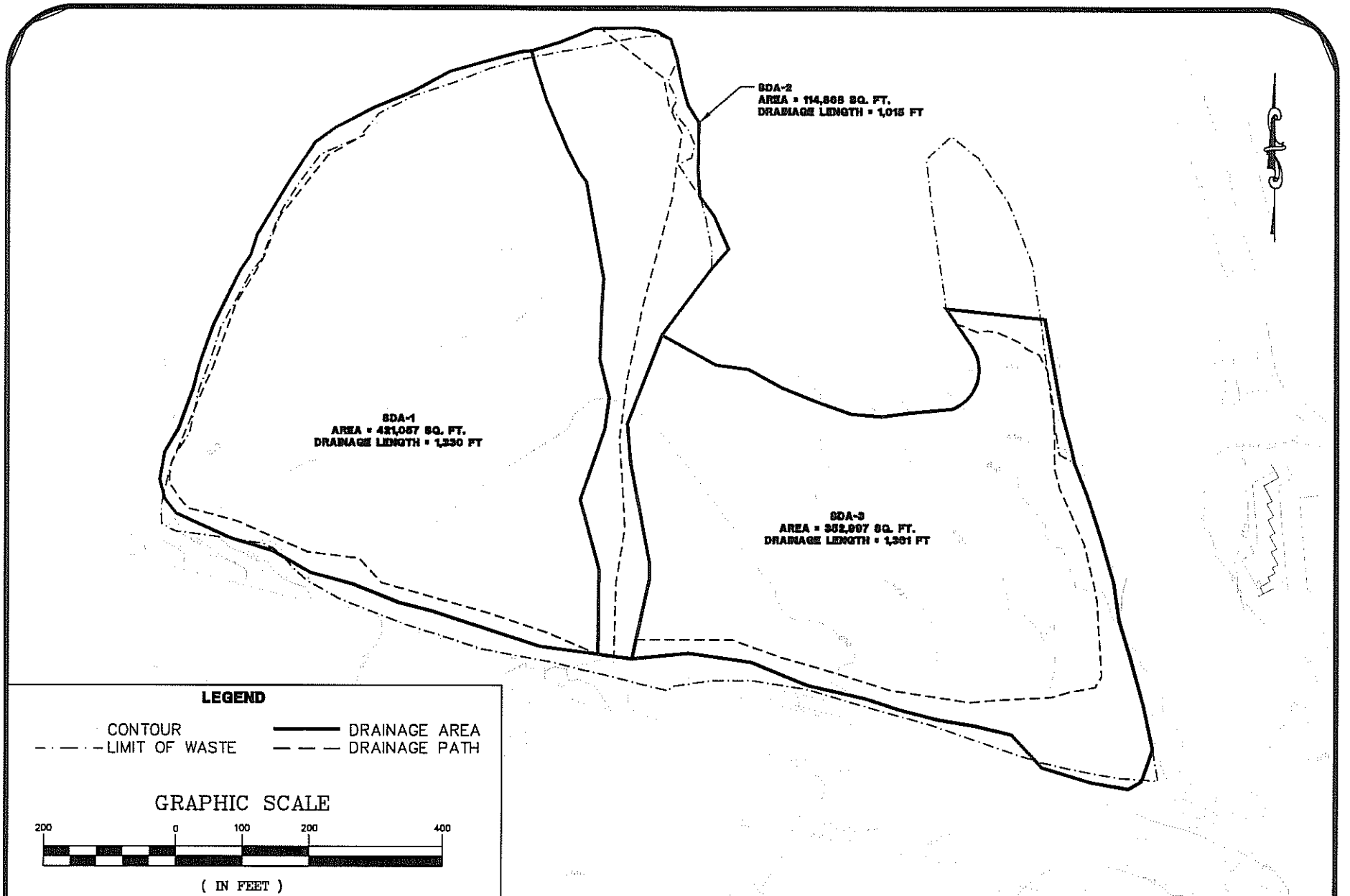
SUMMARY	
Sub-Drainage Area	Flow {Q_{25}} (cfs)
SDA-1	3.87
SDA-2	1.05
SDA-3	3.24

REFERENCES:

1. "Runoff Calculation", Figure, S&ME, September 29, 2010.
2. "Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.

REFERENCE 1

"Runoff Calculation", Figure, S&ME, September 29, 2010.



SCALE: 1" = 200'	DATE: 09/29/10	S&ME 9751 SOUTHERN PINE BLVD. CHARLOTTE, N.C. 28273 (704)523-4726 WWW.SMEINC.COM	**RUNOFF CALCULATION GRADING PLAN** OWL'S DEN LANDFILL LINCOLN COUNTY, NORTH CAROLINA	FIGURE NO. 1
PROJECT NO. 1356-10-028	DRAWN BY: CHR			
ENGINEERING LICENSE NO: F-0176	CHECKED BY:			

REFERENCE 2

"Erosion and Sediment Control Planning and Design Manual", North Carolina Department of Environment and Natural Resources, 2006.

8.03

ESTIMATING RUNOFF

Estimating peak rate of runoff, volume of runoff, and soil loss are basic to the design of erosion and sedimentation control facilities.

There are a number of acceptable methods of determining runoff. Two acceptable methods, the rational method and the Natural Resources Conservation Service (NRCS), formally the SCS, peak discharge method, are described in this section.

The rational method is very simple in concept but relies on considerable judgement and experience to evaluate all factors properly. It is used primarily for small drainage areas (less than 50 acres). The NRCS method is more sophisticated hydrologically and offers a more accurate approximation of runoff, particularly for areas larger than 20 acres. Choice of method for small areas depends primarily on the experience of the designer.

Rational Method

The rational formula is:

$$Q = CIA$$

where:

- Q = peak rate of runoff in cubic feet per second (cfs)
- C = runoff coefficient, an empirical coefficient representing the relationship between rainfall rate and runoff rate
- I = average intensity of rainfall in inches/hour, for a storm duration equal to the time of concentration, T_C
- A = drainage area in acres

The general procedure for determining peak discharge using the rational formula is presented below and illustrated in Sample Problem 8.03a.

Step 1. Determine the drainage area in acres.

Step 2. Determine the runoff coefficient, C, for the type of soil/cover in the drainage area (Table 8.03b).

If the land use and soil cover is homogenous over the drainage area, a C value can be determined directly from Table 8.03b. If there are multiple soil cover conditions, a weighted average must be calculated, or the area may be subdivided.

Step 3. Determine the time of concentration, T_C, for the drainage area. The Kinematic Wave Theory defines time of concentration as the "travel time of a wave to move from the hydraulically most distant point in the catchment to the outlet (Bedient and Huber, 1992)". The formula for the time of concentration is:

$$T_C = (L/(\alpha * (I_e^{\ m-1})))^{1/m}$$

where:

T_C= time of concentration, in minutes. It consists of the total time for overland sheet flow.
L = length of overland flow plane (feet);
I_e = rainfall excess = I_i * C/43,200 (43,200 converts inches per hour to feet per second in the overall equation).
I_i = rainfall intensity;
C = rational runoff coefficients;

This equation contains two sets of parameters that need further definition, α and m. For turbulent flow, which is the normal field condition,

$$m = 5/3 = 1.667$$

$$\alpha = \frac{(1.49 * S^{1/2})}{n}$$

where:

S = slope (ft/ft);
n = Manning's roughness.

Since m will always be 5/3, this equation can be simplified to:

$$T_C = \frac{\left[\dfrac{L}{\alpha\ (I_i * C/43{,}200)^{2/3}}\right]^{3/5}}{60\ \text{(minutes)}}$$

Because both time of concentration and rainfall intensity are unknown variables in one equation, the solution must be found through iterations. The use of a spreadsheet is recommended. An example is shown in Table 8.03a.

Solving for Time of Concentration
Kinematic Wave Theory

Length of overland flow:	400 feet
Manning's "n" surface:	0.020
Average watershed slope:	0.030 foot per foot
Constant alpha:	12.904
Constant "m":	1.667
Rational Coefficient:	0.33

Surface Manning's "n"	
Smooth Surface:	0.011
Bare Earth:	0.020
Fallow:	0.050
Cultivated, ≤ 20% residue:	0.060
Cultivated, > 20% residue:	0.170
Grass, short:	0.150
Grass, dense:	0.240
Grass, Bermuda:	0.410
Woods, light:	0.400
Woods, dense:	0.800

Trial Time of Duration T_r (minutes)	**Rainfall Intensity** i (inches/hour)	**Calculated Time of Concentration** T_C (minutes)
5	7.08	6.67
10	5.66	7.30
15	4.78	7.81
30	3.46	8.89
60 (1 hour)	2.25	10.56
120 (2 hours)	1.33	13.03
180 (3 hours)	0.95	14.91
360 (6 hours)	0.98	14.72
720 (12 hours)	0.34	22.49
1440 (24 hours)	0.21	27.27

Table 8.03a Enter the Rainfall Intensity Values for the corresponding Times of Duration from the Intensity Duration Frequency Tables. Calculate T_C for each Rainfall Intensity. Select the rainfall Intensity that corresponds to the longest Trial Time of Duration that is equal to or less than the calculated Time of Concentration. In this example, the 5-minute Trial Time of Duration is less than the corresponding Calculated Time of Concentration of 6.67 minutes. Therefore use a Rainfall Intensity of 7.08 inches/hour.

In this example, the 5-minute time of duration, and the intensity of 7.08 inches/hour should be selected, because 5 minutes is the longest trial time of duration that is equal to or less than the corresponding calculated time of concentration.

The above method estimates the time of concentration for **overland flow**. After short distances of 400 feet at most, sheet flow tends to concentrate in rills and then gullies of increasing proportions. Such flow is usually referred to as **shallow concentrated flow** (HEC-22, Urban Drainage Manual, FWHA). The NRCS TR-55 Manual (1986) assumed a maximum sheet flow of 300 feet, and the more recent WinTR-55 User Manual (2003) allowed no more than 100 feet of overland flow. Shallow concentrated flow is an important component in determining Time of Concentration.

Both the FWHA and NRCS procedures use similar formulas for the velocity of **shallow concentrated flow**, where...

$$V = 16.1345 * S^{1/2} \text{ (Unpaved)}$$

$$V = 20.3282 * S^{1/2} \text{ (Paved)}$$

where:

V = average velocity (ft/s), and
S = slope (ft/ft)

Flow in gullies empty into **open channels or pipes**. Cross-section geometry and roughness should be obtained for all channel reaches in the watershed. Manning's equation can be used to estimate average flow velocities in pipes and open channels as follows:

$$V = \frac{1.49}{n} (R)^{2/3} (S^{1/2})$$

where:

n = roughness coefficient
V = velocity (ft/s)
R = hydraulic radius (ft)
S = slope (ft)

For a circular pipe flowing full, the hydraulic radius is one-fourth of the diameter. For a wide rectangular channel (width > 10 * depth), the hydraulic radius is approximately equal to the depth.

The travel time for **shallow concentrated flow** and **open channels and pipes** is then calculated from the velocities of those travel segments by the following equation:

$$T_i = \frac{L}{(60 * V)}$$

where:

T_i = travel time for segment i, minutes
L = flow length for segment i, (ft)

Table 8.03b
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, Attached	0.60-0.75
Suburban	0.25-0.40
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.85

Land Use	C
Lawns:	
Sandy soil, flat, 2%	0.05-0.10
Sandy soil, ave., 2-7%	0.10-0.15
Sandy soil, steep, 7%	0.15-0.20
Heavy soil, flat, 2%	0.13-0.17
Heavy soil, ave., 2-7%	0.18-0.22
Heavy soil, steep, 7%	0.25-0.35
Agricultural land:	
Bare packed soil	0.30-0.60
Smooth	0.20-0.50
Rough	0.20-0.40
Cultivated rows	0.10-0.25
Heavy soil no crop	0.15-0.45
Heavy soil with crop	0.05-0.25
Sandy soil no crop	0.05-0.25
Sandy soil with crop	0.10-0.25
Pasture	
Heavy soil	0.15-0.45
Sandy soil	0.05-0.25
Woodlands	0.05-0.25

NOTE: The designer must use judgement to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

Table 8.03c Intensity Duration Frequency

For use with Rational Method**

Murphy, North Carolina 35.0961N, 84.0239W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	4.93	3.94	3.30	2.28	1.43	0.89	0.62	0.38	0.24	0.15
10	6.78	5.42	4.57	3.31	2.16	1.29	0.92	0.55	0.34	0.21
25	7.90	6.29	5.31	3.94	2.62	1.57	1.13	0.68	0.41	0.25
100	9.62	7.64	6.44	4.93	3.40	2.06	1.50	0.90	0.53	0.33

Asheville, North Carolina 35.4358N, 82.5392W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	5.21	4.16	3.46	2.41	1.51	0.89	0.63	0.38	0.24	0.14
10	7.06	5.65	4.76	3.45	2.25	1.30	0.91	0.55	0.34	0.20
25	8.09	6.44	5.45	4.03	2.69	1.56	1.10	0.66	0.40	0.24
100	9.68	7.69	6.48	4.96	3.42	2.00	1.43	0.86	0.50	0.30

Boone, North Carolina 36.2167N, 81.6667W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	5.71	4.57	3.83	2.64	1.66	1.00	0.72	0.48	0.31	0.18
10	7.50	6.00	5.06	3.67	2.39	1.46	1.06	0.69	0.44	0.28
25	8.59	6.85	5.78	4.28	2.85	1.77	1.29	0.83	0.52	0.34
100	10.38	8.25	6.95	5.32	3.67	2.35	1.72	1.08	0.65	0.44

Charlotte, North Carolina, 35.2333N, 80.85W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	5.68	4.54	3.80	2.63	1.65	0.96	0.68	0.41	0.24	0.14
10	7.26	5.80	4.89	3.55	2.31	1.36	0.98	0.59	0.35	0.20
25	8.02	6.38	5.40	4.00	2.66	1.59	1.15	0.70	0.42	0.24
100	9.00	7.15	6.03	4.62	3.18	1.93	1.43	0.87	0.53	0.30

Greensboro, North Carolina 36.975N, 79.9436W

ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	5.46	4.36	3.66	2.52	1.58	0.93	0.66	0.40	0.23	0.14
10	6.85	5.48	4.62	3.35	2.18	1.30	0.92	0.56	0.33	0.20
25	7.39	5.89	4.98	3.69	2.46	1.49	1.06	0.65	0.39	0.23
100	7.93	6.30	5.31	4.07	2.80	1.75	1.24	0.78	0.48	0.29

* ARI is the Average Return Interval.

** Intensity Duration Frequency table is measured in inches per hour.

S&ME

PROJECT NO. 1356-10-028

SHEET NO. 1 / 5

DATE October 01, 2010

JOB NAME Lincoln County – Owl's Den Landfill 2010 Corrective Action

COMPUTED BY CHR

SUBJECT Grass Lined Channels

CHECKED BY KMD

COMPUTATIONS BY:

Signature Cedric Ruhl (KMD)

Date 10/01/2010

Name Cedric Ruhl, P.E.

Title Project Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:

Signature

Date 10/01/2010

Name Joshua M. Bell, P.E.

Title Project Engineer

COMPUTATIONS CHECKED BY:

Signature William M. Harrison

Date 10/01/2010

Name William M. Harrison, E.I.

Title Staff Professional

REVIEWED BY:

Signature Kenneth R. Daly

Date 10/1/10

Name Kenneth R. Daly, P.E.

Title Senior Project Engineer

REVIEW NOTES / COMMENTS:

OBJECTIVE:

The objective of this calculation is to evaluate stability of existing grass-lined channels and proposed outlet areas for sub-drainage areas SDA-1 and SDA-2.

METHOD:

North American Green software will be used to evaluate stability of the existing grass-lined channels and stormwater velocities. The velocity will be compared to allowable velocities for the receiving drainage area.

SUMMARY:

Existing grass-lined channels and receiving drainage areas are anticipated to be stable during the 25-year rainfall event. The construction of channel breaks and riprap aprons are anticipated to increase the likelihood of stability.

CALCULATIONS:

1. Calculate stability of existing grass-lined channels.

Sub-drainage areas SDA-1 and SDA-2 are generally bounded by existing drainage features, generally in the vicinity of the perimeter of the landfill. For the purposes of this calculation, the existing grass-lined channels are assumed to be V-shaped channels with 3H:1V sideslopes. Channel slopes and design flow rates were calculated in the companion package "Runoff". North American Green software was used to estimate stability of the existing grass-lined channels as presented in Reference 1 and summarized in the following table:

TABLE 1: NORTH AMERICAN GREEN OUTPUTS

Sub-Drainage Area	Flow {Q_{25}} (cfs)	Vegetation Stability [Ref. 1]	Soil Stability [Ref. 1]	Flow Area {A} (ft^2) [Ref. 1]	Velocity {V} (ft/s) [Ref. 1]
SDA-1	3.87	1.59	2.98	3.43	1.14
SDA-2	1.05	1.81	9.17	1.79	0.61

2. Discuss stability of receiving area.

The area receiving flow from sub-drainage areas SDA-1 and SDA-2 are wooded slopes. According to NCDENR's BMP Design Manual (Reference 2), typical non-erosive velocities are 2 feet per second for wooded filter strips. The calculated velocities exiting the channels are less than this criteria. S&ME proposes further increasing the likelihood of stability of the receiving area by implementing the following measures:

- Grade low spots at northern perimeter of the landfill to drain in accordance with the Grading Plan.
- Install channel breaks as shown on the Drawings. Channel breaks will decrease the amount of concentrated flow discharging as a point source to the receiving area.
- Install riprap aprons at the channel breaks as shown on the Drawings to decrease flow velocity and flow depth.
- Protect channel breaks as described in the Erosion and Sediment Control Plan until stabilization of the contributing drainage area.

DISCUSSION:

Channel flow depth and outlet velocity are dependent on channel geometry. For the purposes of this calculation, the existing channels were assumed to be v-shaped with 3H:1V sideslopes. Field conditions indicate that existing channels exhibit more of a shallow parabolic shape, which would indicate lower actual outlet velocities than those calculated with the North American Green software.

The stability of the channels and receiving areas are dependent on the vegetative condition of the contributing drainage area. Temporary erosion and sediment control measures should be left in place until the contributing drainage area has been stabilized. The installation of channel breaks and riprap aprons are anticipated to increase the likelihood of stability of the channels and receiving slopes.

CONCLUSIONS:

Existing grass-lined channels and receiving drainage areas are anticipated to be stable during the 25-year rainfall event. The construction of channel breaks and riprap aprons are anticipated to increase the likelihood of stability.

REFERENCES:

1. North American Green, v. 4.3, Erosion Control Materials Design Software.
2. "Stormwater Best Management Practices Manual", North Carolina Department of Environment and Natural Resources – Division of Water Quality, July, 2007.

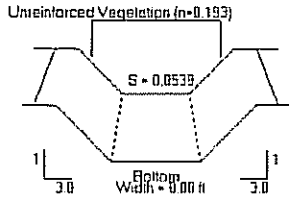
REFERENCE 1

North American Green, v. 4.3, Erosion Control Materials Design Software.

North American Green - ECMDS Version 4.1 | 8/20/2018 02:40 | COMPUTED BY: C. Buhl
PROJECT NAME: Owl's Den Landfill | PROJECT NO.: 1356-10-028
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: SDA-1 | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow	Velocity (fps)	Area (sq ft)	Hydraulic Radius(ft)	Normal Depth (ft)
0.9	24.0	1.14	3.43	0.51	1.07



Not to Scale

LINER RESULTS

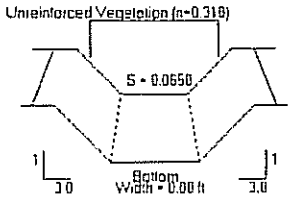
Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		B	Bunc	75-95	5.73	3.60	1.59	STABLE
		Soil	Sandy Loam				0.035	0.012	2.98	STABLE

Back to Input Screen

North American Green - ECMDS Version 4.3	9/20/2010 12:42	COMPUTED BY: C. Buhl	
PROJECT NAME: Owl's Den Landfill		PROJECT NO: 1356-10-028	
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA: SDA-2	DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
1.1	24.0	0.61	1.79	0.37	0.77



Not to Scale

LINER RESULTS

Reach	Matting Type	Stability Analysis	Vegetation Characteristics				Permissible Shear	Calculated Shear Stress (psf)	Safety Factor	Remarks
	Staple Pattern		Phase	Class	Type	Densit				
Straight	Unreinforced	Vegetation		B	Bunc	75-95	5.73	3.17	1.81	STABLE
		Soil	Sandy Loam				0.035	0.004	9.17	STABLE

Back to Input Screen

REFERENCE 2

"Stormwater Best Management Practices Manual", North Carolina Department of Environment and Natural Resources – Division of Water Quality, July, 2007.

13.3.6. Sediment Accumulation

Filter strips can handle low amounts of sediment accumulation by capturing the sediment in the root areas of the vegetation and incorporating it into the soils of the filter strip. Filter strips should not be installed until the contributing drainage area is stabilized. In most instances, a forebay is required prior to the level spreader to capture the sediment prior to entering the filter strip. For filter strips downstream of wet detention basins and infiltration devices, a forebay may not be required if sediment capture is effectively accomplished by the upstream BMP.

13.3.7. Slopes and Velocities

In general, filter strips are most effective on sites with mild slopes. Regulatory program limitations on maximum slopes are identified in section 13.3.4 above.

A key design objective is that the design overland flow velocity must be non-erosive. Overland flow velocity may be managed by the following methods: maintaining low slopes and uniformly sloping grades, limiting flow volumes to appropriate levels, providing good flow distribution, repairing erosion features immediately upon discovery, and maintaining a dense and healthy vegetative cover. Non-erosive velocity is also dependent on soil type, and the designer must consider soil type in evaluating design velocities. Typical non-erosive velocities range from 4 fps if the vegetation is dense grass or undergrowth, and less than 2 fps if the filter strip is wooded.

13.3.8. Plant and Landscape Requirements

To realize the benefits of filter strips, it is essential to maintain a dense, vigorous stand of vegetation. For forest or shrub vegetation, it is recommended that the vegetation generally be deep-rooted, have well-branched top growth, and resistant to damage from either saturation or drought. Vegetation on filter strips receiving street and parking lot runoff must be resistant to deicing chemicals, salts, and heavy metals (tall fescue has been shown to be quite resistant to road salts).

Well-drained soils are preferred, however, with proper soil preparation and selection of appropriate plant species, filter strips can be established successfully on poorly drained soils.

A natural forested area provides good long-term removal of pollutants and priority should be given to preventing the unnecessary removal of trees. Native vegetation often takes longer to establish than turf grass; however, this can be managed by planting the native vegetation early and allowing it to become properly established prior to allowing stormwater onto the BMP.

A grading and vegetation plan must be prepared by an appropriately licensed design professional for all filter strips.

APPENDIX III

REFERENCE:

1. EXISTING CONTOURS FROM AERIAL SURVEY PERFORMED ON JULY 4, 2010. BY SPATIALDATA CONSULTANTS INC.
2. EDGE OF WASTE IS APPROXIMATE AND WAS FIELD DELINEATED BY LINCOLN COUNTY AND S&ME INC.

S&ME
WWW.SMEINC.COM
9751 SOUTHERN PINE BLVD.
CHARLOTTE N.C. 28273
(704) 523-4726

NORTH CAROLINA PROFESSIONAL SEAL 032153 ENGINEER KENNETH R. DALY

NO.	DATE	DESCRIPTION	BY

EXISTING CONDITIONS GRADING PLAN

OWL'S DEN LANDFILL
LINCOLN COUNTY, NORTH CAROLINA

S&ME ENGINEERING LICENSE NO. F-0176	
DRAWN BY: CLD	CHECKED BY: JP
DESIGNED BY: CHR	APPROVED BY: KD
PROJECT NUMBER: 1356-10-028	
SCALE: 1" = 60'	DATE: 10-1-10
DRAWING: 1	OF: 3

DRAWING PATH: Q:\1356\LINCOLN COUNTY\Owls Den Corrective Action Plan (10-028)\Grading Plan and E&S Plan\Grading Plan\SW Measures\Dp02.dwg

OBSCURED

2/3 RIPRAP APRON (TYPICAL)

AREA 2
GRADE TO DRAIN TOWARDS CHANNEL BREAKS/ RIPRAP APRONS

6/3 CHANNEL BREAK

EXISTING SEDIMENT BASIN

4/3 RIPRAP CHANNEL (EXISTING)

4/3 RIPRAP CHANNEL (PROPOSED)

AREA 3
COVER EXPOSED WASTE WITH 2 FEET (MIN) COMPACTED SOIL FILL

CONVENIENCE SITE

AREA 1
GRADE AS SHOWN

AREA 4
GRADE ROAD TO DRAIN SOUTH AND FILL IN DITCH ON NORTH SIDE OF ROAD

PROPOSED BORROW AREA

1/3 SILT FENCE

REFERENCE:

1. EXISTING CONTOURS FROM AERIAL SURVEY PERFORMED ON JULY 4, 2010. BY SPATIALDATA CONSULTANTS INC.
2. EDGE OF WASTE IS APPROXIMATE AND WAS FIELD DELINEATED BY LINCOLN COUNTY AND S&ME INC.

LEGEND

- EXISTING CONTOURS
- PROPOSED GRADE CONTOURS
- PROPOSED DISTURBED AREA
- PROPOSED DISTURBED LIMITS
- EDGE OF WASTE (REF. 2)
- PROPERTY LINE
- FENCE
- SILT FENCE
- EXISTING SLOPE BREAK
- EXISTING RIPRAP CHANNEL
- PROPOSED RIPRAP CHANNEL
- PROPOSED CHANNEL BREAK
- PROPOSED RIPRAP APRON
- POWER POLE
- TREELINE
- STREAM

GRAPHIC SCALE

60 0 30 60 120

(IN FEET)

S&ME
9751 SOUTHERN PINE BLVD.
CHARLOTTE N.C. 28273
(704) 523-4726
WWW.SMEINC.COM

NORTH CAROLINA PROFESSIONAL SEAL 019324 ENGINEER KENNETH R. FOLEY

NO.	DATE	DESCRIPTION	BY

PROPOSED GRADING PLAN
GRADING PLAN

OWL'S DEN LANDFILL
LINCOLN COUNTY, NORTH CAROLINA

S&ME ENGINEERING LICENSE NO. F-0176

DRAWN BY: CLD	CHECKED BY: JP
DESIGNED BY: CHR	APPROVED BY:
PROJECT NUMBER: 1356-10-028	
SCALE: 1" = 60'	DATE: 10-1-10
DRAWING: 2	OF: 3

DRAWING PATH: Q:\1356\LINCOLN COUNTY\Owls Den Corrective Action Plan (10-028)\Grading Plan and E&S Plan\Grading Plan\GW Measures\dp2.dwg

GENERAL SEEDING SPECIFICATIONS

DEFINITION
Controlling runoff and erosion on disturbed areas by establishing perennial vegetative : cover with seed.

PURPOSE
To reduce erosion and decrease sediment yield from disturbed areas, and to permanently stabilize such areas in a manner that is economical, adapts to site conditions, and allows selection of the most appropriate plant materials.

SPECIFICATIONS

SEEDBED REQUIREMENTS
Establishment of vegetation should not be attempted on sites that are unsuitable due to excessive soil compaction, inappropriate soil texture, poor drainage, concentrated overland flow, or steepness of slope until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. The existing soil should have these criteria:

- Enough fine-grained (silt and clay) material to maintain adequate moisture and nutrient supply (available water capacity of at least .05 inches water to 1 inch of soil).
- Sufficient pore space to permit root penetration.
- Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans should be 12 inches or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.
- A favorable pH range for plant growth, usually 6.0 – 6.5.
- Free from large roots, branches, stones, large clods of earth, or trash of any kind. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydro seeded.

If any of the above criteria are not met – i.e., if existing soil is too coarse, dense, shallow or acidic to foster vegetation – special amendments are required. The soil conditioners described below may be beneficial or, preferably, topsoil may be applied.

SEEDBED PREPARATION
Install necessary mechanical erosion and sedimentation control practices before seeding, and complete grading according to the approved plan.

Lime and fertilizer needs should be determined by soil tests. Directions, sample cartons, and information sheets are available through county Agricultural Extension offices. Testing is also done by commercial laboratories.

When soil tests results are not available, follow rates suggested in the seeding specifications shown at right. Application rates usually fall into the following ranges:

- Ground agricultural limestone:
  Light-textured, sandy soils: 1 to 1-1/2 tons/acre
  Heavy-textured, clayey soils: 2-3 tons/acre
- Fertilizer:
  Grasses: 800-1200 lb/acre of 10-10-10 (or the equivalent)
  Grass-legume mixtures: 800-1200 lb/acre of 5-10-10 (or the equivalent)

Apply lime and fertilizer evenly and incorporate into the top 4-6 inches of soil by disking or other suitable means. Operate machinery on the contour. When using a hydro seeder, apply lime and fertilizer to a rough, loose surface.

Roughen surfaces prior to seeding.

Complete seedbed preparation by breaking up large clods and raking into a smooth, uniform surface (slopes less than 3:1). Fill in or level depressions that can collect water. Broadcast seed into a freshly loosened seedbed that has not been sealed by rainfall.

SEEDING
Seeding dates given in the seeding mixture specifications are designated as "best" or "possible". Seedings properly carried out within the "best" dates have a high probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as you deviate from them, the probability of failure increases rapidly. Seeding on the last date shown under "possible" may reduce changes of success by 30-50%. Always take this into account in scheduling land-disturbing activities.

Use certified seed for permanent seeding whenever possible.

Labeling of non-certified seed is also required by law. Labels contain important information on seed purity, germination, and presence of wood seeds. Seeds must meet State standards for content of noxious weeds. Do no accept seed containing "prohibited" noxious weed seed.

Inoculate legume seed with the Rhizobium bacteria appropriate to the species of legume. Apply seed uniformly with a cyclone seeder, drop-type spreader, drill, cultipacker seeder, or hydro seeder on a firm, friable seedbed.

When using a drill or cultipacker seeder, plant small grains no more than 1 inch deep, grasses and legumes no more than 1/2 inch. Equipment should be calibrated in the field for the desired seeding rate.

When using broadcast-seeding methods, subdivide the area into workable sections and determine the amount of seed needed for each section. Apply one-half the seed while moving back and forth across the area, making a uniform pattern: then apply the second half in the same way, but moving at right angles to the first pass.

Mulch all plantings immediately after seeding.

HYDRO SEEDING
Surface roughening is particularly important when hydro seeding, as a roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seedbed preparation is not necessary for hydro seeding operations: large clods, stones, and irregularities provide cavities in which seeds can lodge.

Rate of wood fiber (cellulose) application should be at least 2,000 lb/acre.

Apply legume inoculants at four times the recommended rate when adding inoculant to a hydro seeder slurry.

If a machinery breakdown of 1/2 to 2 hours occurs, add 50% more seed to the tank, based on the proportion of the slurry remaining. This should compensate for damage to seed. Beyond 2 hours, a full rate of new seed may be necessary.

Lime is not normally applied with a hydraulic seeder because it is abrasive. It can be blown onto steep slopes in dry form.

MAINTENANCE
Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for one full year from planting. Inspect seeded areas for failure and make necessary repairs and reseedings within the same season, if possible.

Reseeding--If a stand has inadequate cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over- seed the stand. Consider seeding temporary, annual species if the time of year is not appropriate for permanent seeding.

If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.

Fertilization--On the typical disturbed site, full establishment usually requires re-fertilization in the second growing season. Fine turf requires annual maintenance fertilization. Use soil tests if possible or follow the guidelines given for the specific seeding mixture.

TEMPORARY SEEDING SPECIFICATIONS

Seeding mixture (fall)

Species*	Rate (lb/acre)
Rye Grain (*Secale cereale*)	120

Seeding Mixture (late winter early spring)

Species*	Rate (lb/acre)
Rye Grain (*Secale cereale*)	120
Annual (Korean) Lespedeza (*Kummerowia stipulacea*)	50

Seeding mixture (summer)

Species*	Rate (lb/acre)
German Millet (*Setaria italica*)	40

Seeding dates (Piedmont)

Fall:	Aug. 15 – Dec. 30
Late winter (early spring):	Jan. 1 – May 1 Late
Summer:	May 1 – Aug. 15

Soil amendments
Follow recommendations of soil tests or apply 2,000 lb/acre ground agricultural limestone and 750 lb/acre 10-10-10 fertilizer.

Mulch
Apply 4,000 lb/acre straw. Anchor mulch by tacking with asphalt, roving or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring. tool.

Maintenance
Re-fertilize if growth is not fully adequate. Reseed, re-fertilize and mulch immediately following erosion or other damage.

Pursuant to G.S. 113A-57(2), the angle for graded slopes and fills shall be no greater than the angle that can be retained by vegetative cover or other adequate erosion-control devices or structures. In any event, slopes left exposed will, within 21 calendar days of completion of any phase of grading, be planted or otherwise provided with temporary or permanent ground cover, devices, or structures sufficient to restrain erosion.

Pursuant to G.S. 113A-57(3), provisions for permanent groundcover sufficient to restrain erosion must be accomplished for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction or development.

*REF: 6.10 A,B and C, NC Erosion and Sediment Control Planning and Design Manual, 2006

PERMANENT SEEDING SPECIFICATIONS

Seeding mixture

Species*	Rate (lb/acre)
Tall fescue (*Festuca arundinacea*) (Grass lined Channels)	200
Tall fescue (*Festuca arundinacea*) (Other Areas)	100

Nurse plants
Between May 1 and Aug. 15, add 10 lb/acre German millet (*Setaria italica*) or 15 lb/acre Sudan grass. Prior to May 1 or after Aug. 15, add 40 lb/acre Rye Grain (*Festuca arundinacea*).

Seeding dates

	Best	Possible
Fall:	Aug. 25 – Sept. 15	Aug. 20 – Oct. 25
Late winter:	Feb. 15 – Mar. 21	Feb. 1 –Apr. 15

Fall is best for tall fescue (*Festuca arundinacea*) and late winter or summer for lespedeza. Over seeding of Kobe lespedeza (*Kummerowia striata*) over fall-seeded tall fescue is very effective.

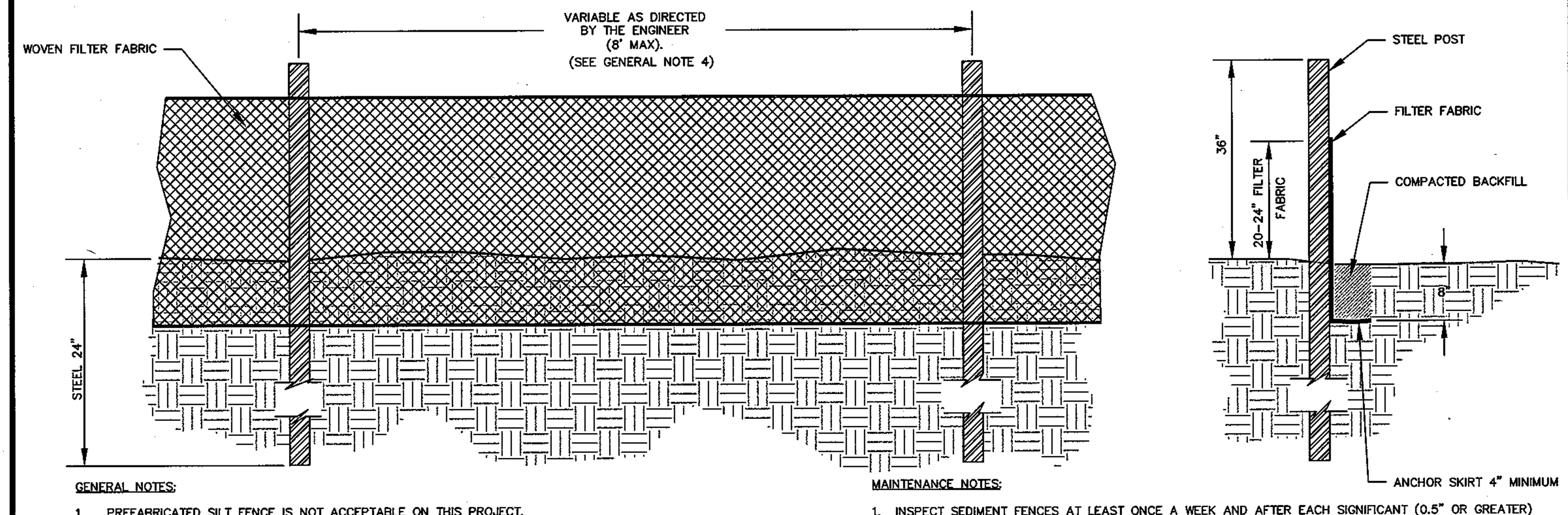
Soil amendments
Apply lime and fertilizer according to soil tests, or apply 4,000 lb/acre ground agricultural limestone and 1,000 lb/acre 10-10-10 fertilizer.

Mulch
Apply 4,000-5,000 lb/acre grain straw or equivalent cover of another suitable mulching material. Anchor mulch by tacking with asphalt, roving, or netting. Netting is the preferred anchoring method on steep slopes.

Maintenance
Re-fertilize in the second year unless growth is fully adequate. May be mowed once or twice a year, but mowing is not necessary. Reseed, fertilize, and mulch damaged areas immediately.

Pursuant to G.S. 113A-57(3), provisions for permanent groundcover sufficient to restrain erosion must be accomplished for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction or development.

*REF: 6.11L NC Erosion and Sediment Control Planning and Design Manual, 2006



GENERAL NOTES:

1. PREFABRICATED SILT FENCE IS NOT ACCEPTABLE ON THIS PROJECT.
2. STEEL POSTS SHALL BE USED ON THIS PROJECT INSTEAD OF WOOD POSTS. STEEL POSTS SHALL BE 5'-0" IN HEIGHT AND BE OF THE SELF-FASTENER ANGLE STEEL TYPE.
3. WOVEN FILTER FABRIC SHALL BE USED WHERE SILT FENCE IS TO REMAIN FOR A PERIOD OF MORE THAN 30 DAYS. FILTER FABRIC FENCE SHALL BE A MINIMUM OF 32" IN WIDTH AND SHALL HAVE A MINIMUM OF 6 LINE WIRES WITH 12" STAY SPACING.
4. SILT FENCE SHALL BE STANDARD STRENGTH FILTER FABRIC WITH WIRE MESH REINFORCEMENT OR EXTRA STRENGTH FILTER FABRIC. WHEN FABRIC IS USED WITH WIRE MESH, 8' CENTERED POSTS MAY BE USED. OMISSION OF THE REINFORCING WIRE IS A CONSTRUCTION CHANGE THAT NECESSITATES MORE POSTS FOR SUPPORT (IE. THE SPACING DISTANCE NEEDS TO BE REDUCED TO NO GREATER THAN SIX (6) FEET APART).
5. TURN SILT FENCE UP SLOPE AT ENDS.
6. THE USE OF SILT FENCE IN AREAS OF CONCENTRATED FLOW IS INAPPROPRIATE

MAINTENANCE NOTES:

1. INSPECT SEDIMENT FENCES AT LEAST ONCE A WEEK AND AFTER EACH SIGNIFICANT (0.5" OR GREATER) RAINFALL. MAKE ANY REQUIRED REPAIRS IMMEDIATELY.
2. SHOULD THE FABRIC OF A SEDIMENT FENCE COLLAPSE, TEAR, DECOMPOSE OR BECOME INEFFECTIVE, REPLACE IT PROMPTLY.
3. REMOVE SEDIMENT DEPOSITS AS NECESSARY TO PROVIDE ADEQUATE STORAGE VOLUME FOR THE NEXT RAIN AND TO REDUCE PRESSURE ON THE FENCE. TAKE CARE TO AVOID UNDERMINING THE FENCE DURING CLEANOUT.
4. REMOVE ALL FENCING MATERIALS AND UNSTABLE SEDIMENT DEPOSITS AND BRING THE AREA TO GRADE AND STABILIZE IT AFTER THE CONTRIBUTING DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.

*REF: 6.62.7 NC Erosion and Sediment Control Planning and Design Manual, 2006

1/3 TYPICAL SILT FENCE INSTALLATION DETAIL
NTS

DEFINITION:

A STRUCTURE DESIGNED TO CONTROL EROSION AT THE OUTLET OF A CHANNEL OR CONDUIT.

PURPOSE:

TO PREVENT EROSION AT THE OUTLET OF A CHANNEL OR CONDUIT BY REDUCING THE VELOCITY OF FLOW AND DISSIPATING THE ENERGY.

CONSTRUCTION SPECIFICATIONS:

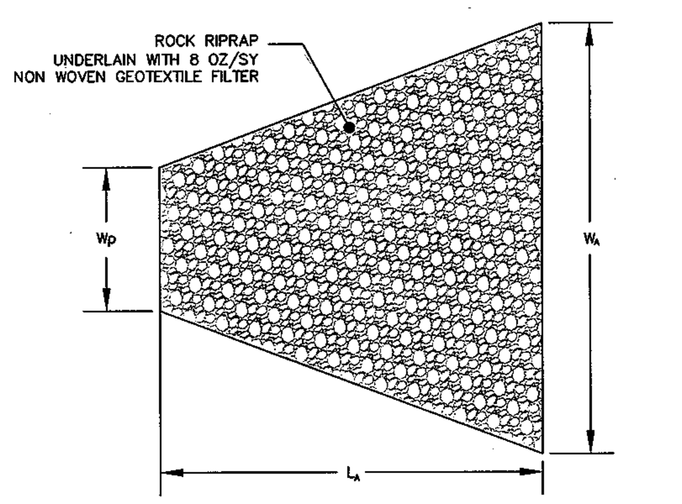
1. ENSURE THAT THE SUBGRADE FOR THE FILTER AND RIPRAP FOLLOWS THE REQUIRED LINES AND GRADES SHOWN IN THE PLAN. COMPACT ANY FILL REQUIRED IN THE SUBGRADE TO THE DENSITY OF THE SURROUNDING DISTURBED MATERIAL. LOW AREAS IN THE SUBGRADE ON UNDISTURBED SOIL MAY ALSO BE FILLED BY INCREASING THE RIPRAP THICKNESS.
2. THE RIPRAP AND GRAVEL FILTER MUST CONFORM TO THE SPECIFIED GRADING LIMITS SHOWN ON THE PLANS.
3. FILTER CLOTH, WHEN USED, MUST MEET DESIGN REQUIREMENTS AND BE PROPERLY PROTECTED FROM PUNCHING OR TEARING DURING INSTALLATION. REPAIR ANY DAMAGE BY REMOVING THE RIPRAP AND PLACING ANOTHER PIECE OF FILTER CLOTH OVER THE DAMAGED AREA. ALL CONNECTING JOINTS SHOULD OVERLAP SO THE TOP LAYER IS ABOVE THE DOWNSTREAM LAYER A MINIMUM OF 1 FT. IF THE DAMAGE IS EXTENSIVE, REPLACE THE ENTIRE FILTER CLOTH.
4. RIPRAP MAY BE PLACED BY EQUIPMENT, BUT TAKE CARE TO AVOID DAMAGING THE FILTER.
5. THE MINIMUM THICKNESS OF THE RIPRAP SHOULD BE 1.5 TIMES THE MAXIMUM STONE DIAMETER.
6. RIPRAP SHALL BE NCDOT RIPRAP CLASS AS SPECIFIED IN THE OUTLET PROTECTION SCHEDULE, OR APPROVED EQUIVALENT. IT SHOULD BE HARD, ANGULAR, HIGHLY WEATHER-RESISTANT AND WELL GRADED.
7. CONSTRUCT THE APRON ON ZERO GRADE WITH NO OVERFILL AT THE END. MAKE THE TOP OF THE RIPRAP AT THE DOWNSTREAM END LEVEL WITH THE RECEIVING AREA OR SLIGHTLY BELOW IT.
8. ENSURE THAT THE APRON IS PROPERLY ALIGNED WITH THE RECEIVING STEAM AND PREFERABLY STRAIGHT THROUGHOUT ITS LENGTH. IF A CURVE IS NEEDED TO FIT SITE CONDITIONS, PLACE IN THE UPPER SECTION OF THE APRON.
9. IMMEDIATELY AFTER CONSTRUCTION, STABILIZE ALL DISTURBED AREAS WITH VEGETATION.

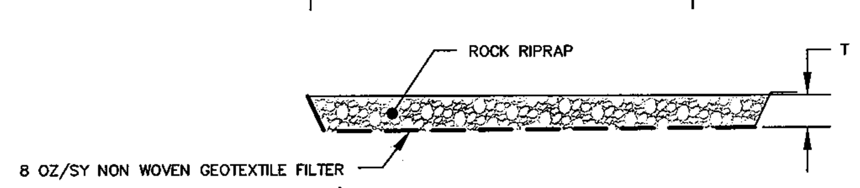
MAINTENANCE:

INSPECT RIPRAP OUTLET STRUCTURES WEEKLY AND AFTER SIGNIFICANT (0.5 INCH OR GREATER) RAINFALL EVENTS TO SEE IF ANY EROSION AROUND OR BELOW THE RIPRAP HAS TAKEN PLACE, OR IF STONES HAVE BEEN DISLODGED. IMMEDIATELY MAKE ALL NEEDED REPAIRS TO PREVENT FURTHER DAMAGE.

REFERENCE:

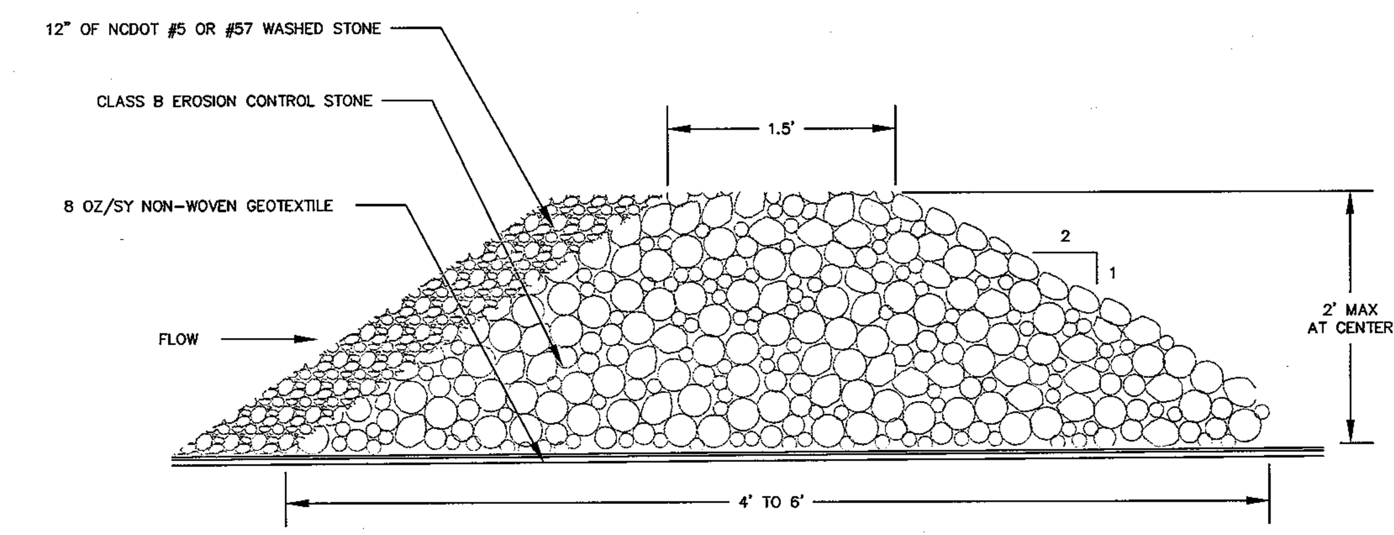
6.41.5 NC EROSION AND SEDIMENTATION CONTROL PLANNING AND DESIGN MANUAL, 2006



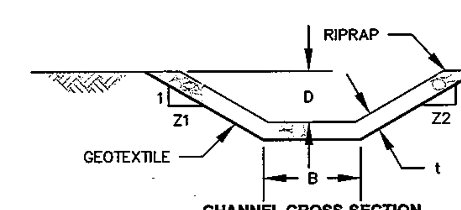


d50 (IN)	dMAX (IN)	T (IN)	L_A (FT)	W. (FT)	Wp (IN)
6	9	13.5	6	4.5	10.5

2/3 TYPICAL RIPRAP APRON
NTS



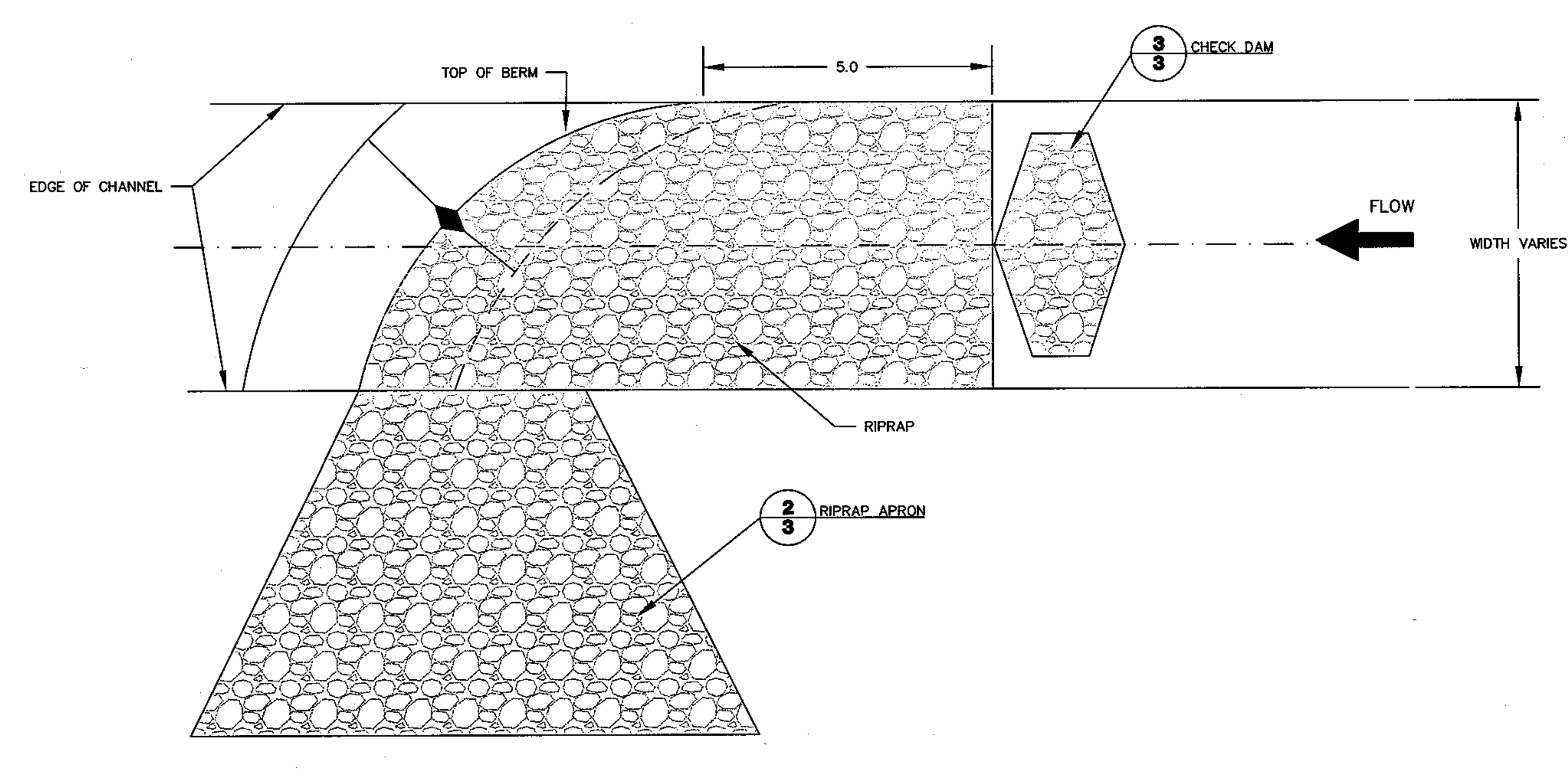
3/3 CHECK DAM
NTS



CHANNEL CROSS-SECTION

BOTTOM WIDTH B (FT)	DEPTH D (FT)	Z1 (FT)	Z2 (FT)	RIPRAP SIZE (d50)	RIPRAP SIZE (dMAX)	RIPRAP THICK. t (IN)
2	2	2	2	6	9	14

4/3 RIPRAP CHANNEL
NTS



5/3 CHANNEL BREAK
NTS

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 032163 KENNETH R. DALY

NO.	DATE	DESCRIPTION	BY

EROSION CONTROL DETAILS
GRADING PLAN

OWL'S DEN LANDFILL
LINCOLN COUNTY, NORTH CAROLINA

DRAWN BY: CLD	CHECKED BY: JP
DESIGNED BY: CHR	APPROVED BY: KRD
PROJECT NUMBER 1356-10-028	
SCALE: NTS	DATE: 10-1-10
DRAWING: 3	OF: 3

DRAWING PATH: G:\1356\LINCOLN COUNTY\OWLS DEN CORRECTIVE ACTION PLAN (10-028)\GRADING PLAN AND E&S PLAN\GRADING PLAN\DETAILS.DWG