CF 44-00

NORTH CAROLINA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WASTE MANAGEMENT

May 26, 1998

Carmen Johnson
44-01 4/11/12

Mr. Jim Giauque
Champion International Corporation
Canton Mill
Box C-10
Canton, North Carolina 28716

Re: Closure Cap Modification
Champion Landfill No. 6, Areas F, G, and H

Dear Mr. Giauque:

The Solid Waste Section hereby approves the modification to the closure cap system for Champion Landfill 6, Areas F, G, and H. This approval applies only to the design of the landfill closure cap system and should not be regarded as an evaluation of the success of the cap's performance as a corrective action tool. This correspondence does not terminate continuance of assessment activities.

Champion International Corporation, Canton Mill shall notify the Section when the proposed cap is installed and closure of the landfill is completed. A landfill closure letter will then be forthcoming which will specify post-closure activities.

If I can be of further assistance or if you have any further questions or comments, please contact me at (919) 733-0692, ext.255.

Sincerely,

James C Coffey

James C. Coffey, Head
Permitting Branch
Solid Waste Section

cc: Mark Poindexter
Julian Foscue
Tim Jewett
Jim Patterson

NCDENR

JAMES B. HUNT JR.
GOVERNOR

WAYNE MCDEVITT
SECRETARY

WILLIAM L. MEYER
DIRECTOR

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44-CG

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NCDENR

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WAYNE MCDEVITT
SECRETARY

WILLIAM L. MEYER
DIRECTOR

March 13, 1998

Mr. Jim Giauque
Champion International Corporation
Canton Mill
Box C-10
Canton, North Carolina 28716

Re: Review Comments
Closure Cap Design
Champion Landfill No. 6, Areas F, G, and H

The Solid Waste Section has completed a review of the closure cap design for Landfill No.6, Areas F, G, and H. Based on this review, the following comments must be addressed.

1. A cover soil stability analysis was included in Appendix C. However, this analysis was not performed for a critical slope of 3:1. Please revise to ensure stability of soil on steeper sideslopes. Also, evaluate stresses in sideslope materials to ensure no failures on critical slope.
2. Detail B, Cap Edge with Anchor, does not indicate that geonet will be placed in anchor trench. Please comment if this is indeed the case.
3. Detail E, Storage Pad, indicates 12" of gravel underlain by 24" of common borrow. Area H cross sections indicate a gravel pad with a thickness of three feet. Please correct discrepancy.

If you have any questions or comments, please contact me at (919) 733-0692, ext.259.

Sincerely,

Sherri L. Coghill
Environmental Engineer
Solid Waste Section

cc: Mark Poindexter
Julian Foscue
Jim Patterson

401 OBERLIN ROAD, SUITE 150, RALEIGH, NC 27605
PHONE 919-733-4996 FAX 919-715-3605

Canton Mill
Box C-10
Canton, North Carolina 28716


**Champion**
Champion International Corporation

April 27, 1998

Ms. Sherri L. Coghill
North Carolina Department of Environment and
Natural Resources
Solid Waste Section
401 Oberlin Road, Suite 150
Raleigh, North Carolina 27605

Dear Ms. Coghill:

The attached analysis was prepared by Sevee & Maher Engineers, Inc., in response to the questions posed in your letter dated March 13, 1998, regarding the Champion International Corporation Landfill Number 6, Areas F, G, and H closure cap design. Each of your questions has been answered with attachments as appropriate.

Upon receipt of Solid Waste Section approval, it is Champion's intention to complete the capping of Areas F, G, and H per the submitted design by the end of the third quarter 1998, to take advantage of summer and fall weather as well as the fall seeding window.

Please call me at 828-646-2028 should you have additional questions.

Sincerely,

Jim Giauque

Attachements
file:coghil49.doc

Copy: Derric Brown

SME

*Sevee & Maher Engineers, Inc.*
*Waste Management and Hydrogeologic Consultants*

April 16, 1998

98024
040798jg.doc

Champion International Corporation
Attn: Mr. Jim Giauque
P.O. Box C-10
Canton, North Carolina 28716

Subject: Champion Landfill No. 6, Areas F, G, and H
Closure Cap Design

Dear Jim:

As requested, Sevee & Maher Engineers, Inc. (SME) has prepared responses to comments made by Sherri Coghill of the North Carolina Department of Environment and Natural Resources (NCDENR) in a letter dated March 13, 1998. For your convenience, our responses will follow the format of the NCDENR correspondence.

**NCDENR LETTER – MARCH 13, 1998**

1. ***A cover soil stability analysis was included in Appendix C. However, this analysis was not performed for a critical slope of 3:1. Please revise to ensure stability of soil on steeper sideslopes. Also, evaluate stresses in sideslope materials to ensure no failures on critical slope.***

   Response. A stability analysis for the sideslopes inclined at 3H:1V has been prepared and is included as Attachment A. The result of the analysis indicates a factor of safety of 1.3. In regards to stresses in the liner, the stability analysis of the cover system did not utilize the tensile strength of the liner material in calculating the factor of safety. Since the calculated factor of safety is greater than 1.0, the tensile strength of the PVC liner is not needed to maintain the cover soil on the slope.



*4 Blanchard Road P.O. Box 85A Cumberland Center, ME 04021 (207) 829-5016 FAX (207) 829-5692 www.smemaine.com*

2. ***Detail B, Cap Edge with Anchor, does not indicate that geonet will be placed in anchor trench. Please comment if this is indeed the case.***

   Response. Detail B has been changed to show the geonet extending into the anchor trench. The design intended for the geonet to be anchored as shown in the attached Detail B, but was shown in error in the original drawings.

3. ***Detail E, Storage Pad, indicates 12" of gravel underlain by 24" of common borrow. Area H cross-sections indicate a gravel pad with a thickness of three feet. Please correct discrepancy.***

   Response. The sections on engineering drawing C-200 have been revised to show the two soil layers which make up the storage area. A copy of the revised plan is attached.

If you have any questions, please do not hesitate to call.

Very truly yours,

SEVEE & MAHER ENGINEERS, INC.

Guy H. Cote, Jr., P.E.
Chief Engineer

attachments

SME

Sevee & Maher Engineers, Inc.
Waste Management and Hydrogeologic Consultants

98024
040698.doc

MEMO TO: Guy Cote

MEMO FROM: Matt Muzzy

DATE: April 7, 1998

SUBJECT: LINER STABILITY ANALYSIS

The purpose of this memo is to respond to the North Carolina Department of Environmental and Natural Resources (NCDENR) review comment No. 1 as presented in the March 13, 1998 letter from Sherri L. Coghill to Jim Giauque of Champion International Corporation (Champion). Comment No. 1 is relative to the closure cap design for Landfill No. 6 Areas F, G, and H and reads as follows:

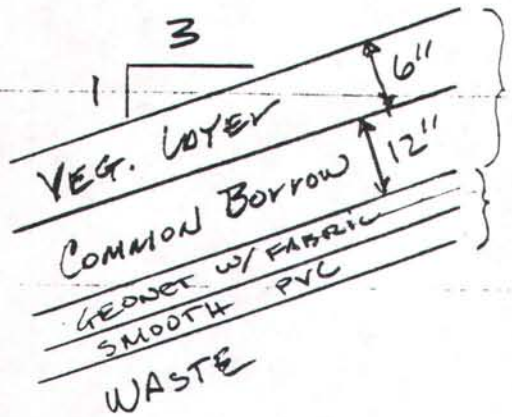
> A cover soil stability analysis was included in Appendix C. However, this analysis was not performed for a critical slope of 3:1. Please revise to ensure stability of soil on steeper sideslopes. Also, evaluate stresses in sideslope material to assure no failures on critical slope.

Based on review of the grading plan and details for the closure design (see Landfill No. 6 Closure Plan for Areas F, G, and H dated September 12, 1997), a 3H:1V slope occurs adjacent to portions of the drainage ditch which is located along the southwest margin of Area H. To evaluate this slope condition, the same geotechnical properties and evaluation guidance described in the September 1997 closure plan were used, while substituting a worst case slope length of 40 feet and a slope angle of 18.5°. The resulting safety factor for the shortened but steeper cover condition was calculated to be 1.3 (see attached calculations). In calculating the safety factor for the 3H:1V slope, no tensile forces in the PVC liner and/or geonet overlying the PVC liner were utilized which would effectively increase the calculated safety factor.

Champion/Canton/Area FGH - Landfill No 6
Job No 98024

M Muzzy
4/6/98

→ Evaluate Slope Stability for Cover at 3H:1V slope. Worst case slope length = 40 feet based on grading plan use following cover conditions




$\gamma_{TS} = 57.6$ pcf
$\Phi = 32°$
$\delta = 21°$
$\Phi = 32°$

AS PER INITIAL DESIGN EVAL

Following guidence in EPA/625/4-91/025

$$F_S = \left(-b + \sqrt{b^2 - 4ac}\right) \div 2a$$

$$a = 0.5\,(57.6\text{pcf})(40\text{ft})(1.5\text{ft})\left(\sin 2(18.5^\circ)\right)^2$$

$$\boxed{a = 625}$$

$$b = -[(57.6\text{pcf})(40\text{FT})(1.5\text{FT})(\cos 18.5)^2(\tan 21)(\sin 2(18.5))$$
$$+ Ca\cos^0 + 120(40)(1.5)(\sin 18.5)^2 \tan 32$$
$$* (\sin 2(18.5)) + 2c\cos^0$$
$$+ 120(1.5)^2 \tan 32$$

$$\boxed{b = -929}$$

$$c = [(57.6\text{pcf})(40)(1.5)(\cos 18.5)(\tan 21) + Ca\cos^0]$$
$$* (\tan 32 (\sin 18.5)(\sin 2(18.5))$$

$$\boxed{c = 150}$$

$$FS = \frac{-(-929) \pm \sqrt{929^2 - 4(625)(150)}}{2(625)} = 1.3$$

# LANDFILL NO. 6
# CLOSURE PLAN FOR
# AREAS F, G, AND H
# CANTON, NORTH CAROLINA

## CHAMPION INTERNATIONAL CORP.

## CANTON, NORTH CAROLINA



## SEPTEMBER 12, 1997



Prepared by

Sevee & Maher Engineers, Inc.
Cumberland Center, Maine

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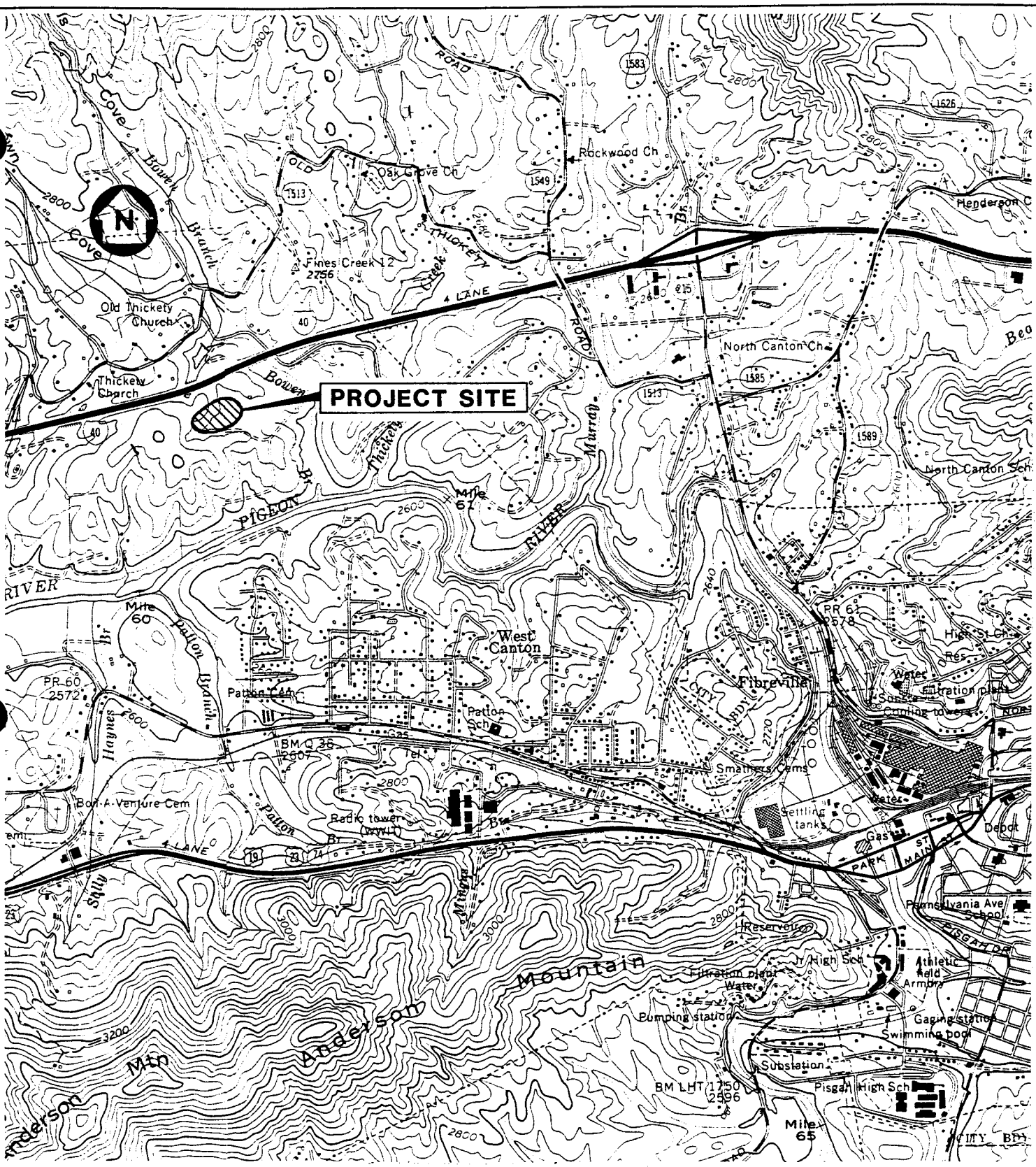
## 1.0 INTRODUCTION

Champion International Corp. (Champion) operates a pulp and paper mill in Canton, North Carolina. The industrial non-hazardous process solid wastes generated by the mill are landfilled at a company-owned landfill in Canton, North Carolina, referred to as Landfill No. 6 (see Figure 1-1). Permitted wastes include wastewater treatment plant sludge, lime mud, boiler fly ash and cinders, wood waste, and asbestos-containing materials. Landfill No. 6 was initially permitted for construction and operation in February 1984, Permit #44-06.

Landfill No. 6 is divided into eight landfilling areas designated as Areas A through H. Currently, Areas B, C, F, G, and H have been constructed according to the original design and landfilled to capacity. In addition, Areas F and G have been capped according to the original design. However, groundwater monitoring and a recent hydrogeologic study indicate that Areas F, G, and H are potentially impacting the quality of the local groundwater regime. The source entering the groundwater from these areas is a function of the amount of water infiltrating through the cover and waste. Essentially eliminating the infiltration is accomplished by new capping systems within Areas F and G, and installing a capping system within Area H.

Champion retained the services of Sevee & Maher Engineers, Inc. (SME) to evaluate capping alternatives for Areas F, G, and H each of which contain lime and asbestos-containing materials. The alternatives assessment concluded that installation of a




BASE MAP ADAPTED FROM 7.5 MIN.
USGS TOPOGRAPHIC QUADRANGLES
CANTON, NC - 1990
CLYDE, NC - 1978

0 2000 4000 FEET

FIGURE 1-1
SITE LOCATION PLAN
CHAMPION INTERNATIONAL CORPORATION
CANTON, NORTH CAROLINA

SEVEE & MAHER ENGINEERS

geomembrane liner would prove effective in reducing infiltration from rainfall by 99.7 percent as estimated by the Hydrologic Evaluation of Landfill Performance (HELP) model. Other capping alternatives such as a low permeable soil cap or a composite cap (soil and geomembrane) were found to be just as effective, however, much more costly. The primary reason the costs were higher for the other alternatives was the cost of the low permeable soil. There are no local sources of low permeable soil, which meant the local soils would require soil amendments (i.e. bentonite) to meet the specifications. The cost of the soil amendments as well as specialized construction techniques raised the cost for low permeable soil options. Likewise, the use of a geocomposite, i.e. geonet and non-woven fabric, is being used as a substitute for sand in the drainage layer above the geomembrane. The cost of importing sand was also very high.

This document has been prepared by SME to serve as a closure plan for Areas F, G, and H. Specifically, this document contains:

- Closure design;
- Stormwater and erosion control management; and
- Construction management.

# 2.0 CLOSURE DESIGN

## 2.1 Development Concept

The closure plan for Areas F, G, and H was developed to minimize leachate generation through placement of a low hydraulic conductivity cover system and thereby reduce the potential for impact to groundwater. Currently, a large percentage of the precipitation which falls onto the site infiltrates through the waste, becomes leachate, and enters the groundwater system. Generation of the majority of this leachate will be avoided once the cover system described herein is implemented.

The closure design of the site was developed from the site specific conditions, availability of materials in the Canton area, along with the understanding of the past operating procedures of the site, and the landfill waste stream. A low hydraulic conductivity cover system and site maintenance are effective closure elements for this site. Closure of Areas F, G, and H will include the following activities.

- Final grading and shaping of the site to approximately 18 inches lower than the final contours shown on the Drawings;

- Placement of the proposed final cover in accordance with Section 2.3 of this document and as shown on the Drawings; and

- Seeding and fertilizing the site in accordance with the seeding specifications described in Section 2.4 of this document.

The principal goals for the closure plan are as follows:

- To minimize future generation of leachate; and

- To provide a cover system suitable for development of the grass crop which will prevent erosion.

Of these objectives, the requirement to minimize future leachate generation is the most important.

## 2.2 Final Grading

The existing landfills will be regraded to approximately 18 inches below the proposed final contours shown on the Drawings. Grading of the landfills will be performed to achieve a minimum 5 percent grade along the top of the landfill, and a maximum 33 percent grade along the landfill sideslopes. Prior to placement of the final cover material, a surveyor will check the elevations to assure that the proper grades exist, and that there are no low areas or depressions within the site.

## 2.3 Final Cover System

The proposed final cover system on Areas F, G, and H is considered an alternative cap by the NCDEHNR solid waste regulations, 15A:13B.1627(2). The regulations require a minimum of 18 inches of low permeable soil as part of the cover system. The proposed design substitutes a geomembrane liner for the low permeable soil. The geomembrane liner will achieve an equivalent or greater reduction in infiltration than the low permeable soil. The proposed final cover system from bottom to top will consist of a 30-mil polyvinyl chloride (PVC) liner, a geonet sandwiched between non-woven geotextiles, 12 inches of common borrow, and overlain by 6 inches of a plant growth medium. A cross-section through the final cover system is shown on Drawing C-300 and Figure 2-1. The only exception to the cover described above is in a portion of Area H where a clean material storage pad will be constructed over the liner. For the material storage pad a heavier and thicker non-woven fabric will be used over the PVC liner along with 2 feet of common borrow and 12 inches of gravel as a traffic surface. The thickness of the base and subbase material will provide adequate protection from the weight of construction vehicles using the area.

The geonet layer above the geomembrane liner will serve two purposes: (1) it will protect the liner from punctures; and (2) provide a conduit for water to drain off the liner which infiltrates the cover soil. To assure proper drainage of water which infiltrates the cover soil, the cover system is sloped a minimum of 5 percent. Once the water in the geonet reaches the perimeter of the cap, the water will drain into a perimeter drain which empties into the surface drainage structures on-site.

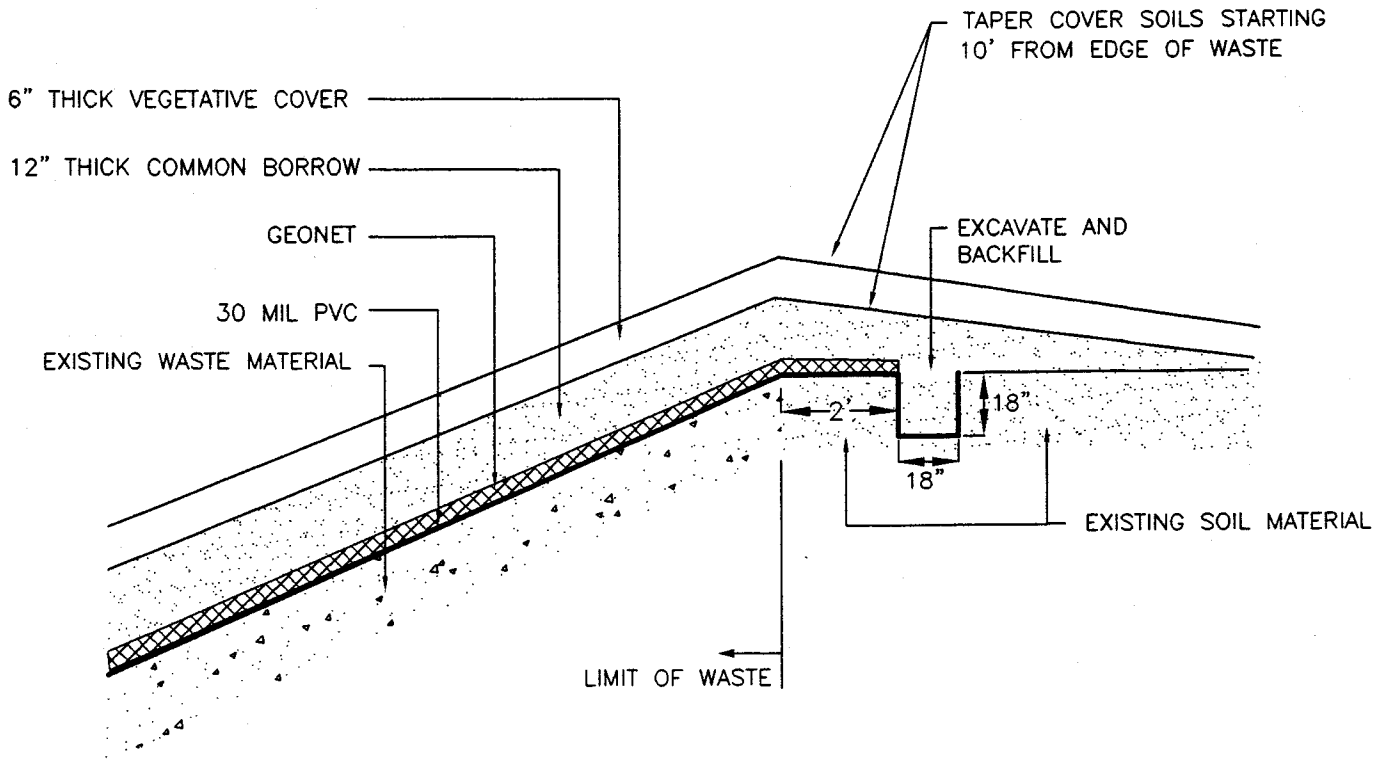



FIGURE 2-1
LANDFILL CLOSURE SECTION
CHAMPION INTERNATIONAL CORPORATION
CANTON, NORTH CAROLINA

SEVEE & MAHER ENGINEERS, INC.

DWG: CANSP972 SOURCE:

D:\CHP\NC\ACAD\CANSP972.dwg Tue Sep 09 16:04:23 1997

The 6-inch layer of plant growth medium will be consistent with local topsoil material and free of frozen material, debris, trash, stumps, rocks, and roots. Application of seed, lime, fertilizer, and mulch will be in accordance with the engineering specifications in Appendix B.

The design of a landfill closure with a geomembrane liner requires attention to stability of the cover material over the liner and liner compatibility with the waste. The primary concern is sliding of the cover material down the slope. This is especially critical when slopes are on the order of 33 percent (3H:1V). The maximum slope for Areas F, G, and H is 12 percent and the average slope length is 220 feet. A slope analysis was conducted using a free body diagram as outlined in an U.S.EPA publication "Design and Construction of RCRA/CERCLA Final Covers, EPA/625/4-91/025". In addition, the analysis was conducted assuming the soil layers were saturated (buoyant unit weight). The factor of safety calculated with the proposed design is 3.3, which is acceptable, i.e. a factor of safety greater than 1. The results of the stability analysis are in Appendix C.

Liner compatibility with the waste is generally not an issue in cover systems since the liner is not generally in contact with the waste. This is the case for Areas F and G where the liner is in contact with the existing soil cover. However, for Area H the liner will be in contact with the lime waste. The PVC liner was found to be compatible with the pH of the waste based on the manufacturer's reference (see Appendix C).

## 2.4 Seeding

All areas disturbed during placement of the final cover system will be seeded. Seeding will normally occur between April 30 and September 30. All surface water runoff control structures such as drainage ditches, berms, and culverts are to be constructed prior to seeding. All grading will also be performed prior to seeding. The top layer of soil should be loosened by raking, discing, or other acceptable means before seeding. Lime and fertilizer will be harrowed or disced into the soil at a minimum of 3 inches. Application rates for lime and fertilizer will follow the engineering specifications (Appendix B), or as needed based on testing. If the site is hydroseeded, lime, fertilizer and seed can be applied simultaneously. The seed mixture to be used will follow the engineering specifications. The seed will be applied uniformly with a cyclone seeder, drilled, cultipack seeder, or hydroseeder. Seeds shall not be planted if there is a danger of frost shortly after seed germination. Maximum seeding depth is ¼ inch when using methods other than hydroseeding. Wood fiber, cellulose mulch, or hay mulch will be spread uniformly upon completion of the seedbed preparation, liming, fertilization, and seeding. The mulch may be anchored in-place by uniformly applying an acceptable mulch binder such as Curasol or Terr-Tac. If germination is unsuccessful (less than 75 percent catch) within 30 days of seeding, or there is unsatisfactory catch in the next year, Champion will reseed the area in accordance with the seeding specifications contained herein.

Champion will initiate capping of Areas F, G, and H in the second quarter of 1998 (contingent upon regulatory approval and weather conditions). Champion will utilize qualified personnel or retain the services of a Professional Engineer certified in the State of North Carolina and familiar with the various aspects of landfill design and closure, to serve as their on-site representative during closure of the site. The on-site representative will provide full-time observation of the proposed closure activities and will be responsible for quality control enforcement and construction documentation at the site. The general contractor will be responsible for supplying the required labor, material, and equipment for the installation of the final closure system described above. Services of a general contractor will be procured through a competitive bid process. Bid packages for the solicitation of construction services will require the contractor to identify and demonstrate familiarity and experience with the various aspects of landfill construction.

To control the quality of the soil materials and geomembrane used in the landfill construction, a quality assurance/quality control (QA/QC) program will be implemented. The program will include source testing to demonstrate compliance with the materials specifications and construction testing to demonstrate that materials have been properly installed.

2.5.1 Soil QA/QC.

2.5.1.1 Source Testing

The soil materials used for the landfill closure will be tested at the source prior to being delivered on-site, to demonstrate compliance with the material specification. Samples will be collected at the borrow source in accordance with the methods specified by ASTM D 420 (investigation and sampling soil and rock), and tested by the contractor prior to the Owner's acceptance of the materials. The contractor will be required to have the test performed by an independent testing laboratory. The soil material specifications and frequency of testing are presented in the engineering specifications.

2.5.2 Geomembrane QA/QC. The quality assurance and quality control of the facility's geomembrane liner will be as described in Section 02771 of the construction specifications contained in Appendix B of this report. The liner QA/QC will include: conformance testing of materials delivered to the site; daily field tests of welding equipment; and seam samples for destructive testing.

2.5.3 Weekly Inspection Reports. Weekly inspection reports will be prepared by the Owner's representative during the closure of the landfill. The reports will include material test results, summary of contractor submittals, summary of weekly progress and progress made to date, and anticipated work items for the following week. Copies of the reports will be provided in the construction certification report.

2.5.4 Photographic Documentation. To provide documentation of the landfill closure, photographs will be taken periodically of the closure construction. Copies of the photographs will be provided in the construction certification report.

2.5.5 Record Drawings. Upon completion of the landfill closure, record drawings will be prepared for the facility. The drawings will be sealed by a State of North Carolina Professional Engineer and will be submitted to the NCDEHNR within 30 days of closure completion.

2.5.6 Final Construction Certification and Report. A final construction report will be submitted by Champion to the NCDEHNR within 30 days following the completion of closure construction at the landfill. The report will include written certification signed and stamped by the engineer supervising project inspection, that the site has been closed in accordance with the approved plans and specifications.

## 2.6 Leachate and Gas Management

Leachate is primarily generated at the landfill site through precipitation falling onto and infiltrating into the landfill. Leachate will be managed through the placement of a low hydraulic conductivity cover system.

The generation of gas and associated odors has not been a problem at the site in the lime storage areas to date and, therefore, no gas management/venting system will be incorporated into the final cover system.

## 2.7 Stormwater Management/Erosion Control

To design the necessary surface water control structures, stormwater runoff calculations for the site were performed utilizing the methodology outlined by the USDA Soil Conservation Service's (SCS) Technical Release No. 55 (TR-55, Urban Hydrology for Small Watersheds, June 1986 Revision). A 100-year/24-hour Type II storm with average Antecedent Runoff Conditions was used to calculate the runoff characteristics of the appropriate drainage areas. Calculations used to determine design flow rates along with TR-55 work sheets, are attached in Appendix C of this document.

Erosion control measures, including the use of stone check dams, siltation fence, and riprap aprons will be implemented. A permit will be secured from the Haywood County Soil and Erosion Control Authority prior to conducting the work. In addition, the following erosion control procedures will be followed during closure construction operations and after site closure has been completed.

- All soil erosion and sediment control measures will be performed in strict accordance with the "North Carolina Erosion and Sediment Control Planning and Design Manual," including the latest data from the SCS.

- Removal of trees, brush, and other vegetation, as well as disturbance of soil, will be kept to a minimum during site closure.

- Acceptable existing topsoil will be stripped and stockpiled for reuse as final cover. Topsoil suitable for reuse will be stockpiled on-site in a manner that natural drainage is not obstructed and no off-site sediment damage will result.

- During grading operations, the site will be brought to approximate finish grades and stabilized without extended delays. This includes the application of mulch to all surfaces designated to be revegetated.

- Erosion and sediment control measures such as stone check dams and siltation fencing will be installed as shown and/or adjusted to suit construction immediately after a cut or fill slope has been created.

- Silt fencing will be inspected after prolonged rainfall events and repairs made as necessary. Sediment deposits will be periodically removed from the upstream side of the silt areas. This sediment will be spread and stabilized in areas of the site not subject to erosion. Silt fencing will be replaced as necessary to provide proper filtration action.

- Riprap will consist of field stone or rough unhewn quarry stone of approximately rectangular shape. Stones will weigh from 5 to 50 pounds

and approximately 50 percent of the stones by volume will exceed a unit weight of 90 pounds or 12 inches in diameter, unless otherwise noted on the construction drawings.

- Immediately following final grading of all common borrow, all graded or disturbed areas will receive 6 inches of topsoil and will be seeded to provide a permanent vegetative cover.

## 2.8 Design Plans and Technical Specifications

Design plans showing the landfill's existing site topography, proposed final grading (elevations and sideslopes), drainage control structures, monitoring wells, and landfill cross-sections are contained in Appendix A. In addition, an area map at a scale of 1 inch equals 100 feet, showing the site in relation to existing surrounding natural or manmade features, including the limits of the proposed cover system, property boundary, floodplain boundaries, existing buildings and structures, roads, and surface water, etc., is also contained in Appendix A. Technical specifications for the proposed closure activities are contained in Appendix B.

## 3.0 LONG-TERM (POST-CLOSURE) MAINTENANCE

The subsections which follow describe the various activities which must be done to insure the long-term integrity of the landfill subsequent to final closure.

### 3.1 Mowing

To prevent deep rooted tree growth, the closed portions of the landfill and drainage ditches will be mowed.

### 3.2 Site Inspection

Closed areas will be inspected quarterly for a period of at least three years to insure the cover system integrity is maintained against erosion and other problems. The inspection will include an examination of the following items:

- surface drainageways
- surface grading
- grass growth

Each inspection will include notation of any problems and recommended remedial actions; please refer to Table 3-1 for maintenance inspection checklist. Following the three years,

an inspection frequency of twice per year will be sufficient unless major problems develop, whereupon more frequent inspections will be made.

TABLE 3-1
CHAMPION INTERNATIONAL CORP.
**LANDFILL INSPECTION RECORD**

REPORTED BY: _____ DAY S M T W T F S
DATE: _____
LOCATION: _____ WEATHER: _____
REASON FOR INSPECTION: _____ TEMP.: _____
_____
_____
_____

| | PASS | CORRECTIVE ACTION REQUIRED |
|---|---|---|
| **ACCESS ROADS** | | |
| GATES | _____ | _____ |
| ROAD SURFACE | _____ | _____ |
| DITCHING | _____ | _____ |

CORRECTIVE ACTION: _____
_____
_____
_____
_____
_____
_____

COMMENTS: _____
_____
_____
_____
_____
_____
_____

| | PASS | CORRECTIVE ACTION REQUIRED |
|---|---|---|
| **CLOSURE AREAS** | | |
| SLOPE STABILITY | _____ | _____ |
| VEGETATION | _____ | _____ |
| EROSION | _____ | _____ |
| DITCHES | _____ | _____ |

CORRECTIVE ACTION: _____

COMMENTS: _____

FOLLOW-UP INSPECTIONS OF PREVIOUSLY REPORTED DEFICIENCIES:

| ITEM | EXISTING CONDITIONS |
|---|---|

**DISTRIBUTION:**

APPENDIX A

ENGINEERING DRAWINGS

Under Seperate Cover

# APPENDIX B

# ENGINEERING SPECIFICATIONS

SPECIFICATIONS

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# SECTION 02200

# EARTHWORK

## 1. GENERAL

### 1.1 RELATED DOCUMENTS:

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

### 1.2 DESCRIPTION OF WORK:

Extent of earthwork is indicated on drawings.

Definition: "Excavation" consists of removal of material encountered to subgrade elevations indicated and subsequent disposal or replacement (backfill) of materials removed.

### 1.3 QUALITY CONTROL:

1.3.1 Codes and Standards: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

1.3.2 Testing and Inspection Service: Owner will engage soil testing and inspection service for quality assurance testing during earthwork operations.

### 1.4 SUBMITTALS:

1.4.1 Test Reports-Earth Materials: Test reports on the following borrow materials to be utilized.

- o #67 Stone:
  - Grain Size (D422) - 1/3000 cy
- o Common Borrow (silty sand, sandy silt or clayey soil):
  - Grain Size (D422) - 1/3000 cy

1.4.2 Explosives Plan: Prior to blasting, submit all blasting plans for approval. Note: No blasting is anticipated.

### 1.5 JOB CONDITIONS:

1.5.1 Site Information: Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between soil borings. It is expressly understood that Owner will not be responsible for interpretations or conclusions drawn therefrom by Contractor. Data are made available for convenience of Contractor.

Additional test borings and other exploratory operations may be made by Contractor at no cost to Owner.

1.5.2 Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

Do not interrupt existing utilities serving facilities occupied and used by Owner or others, during occupied hours, except when permitted in writing by Owner's Representative and then only after acceptable temporary utility services have been provided.

Provide minimum of 48-hour notice to Owner's Representative, and receive written notice to proceed before interrupting any utility.

Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.

1.5.3 Use of Explosives: (None anticipated)

General: This work shall consist of furnishing, placing and detonating dynamite in places directed for the excavation of related work items in accordance with these specifications and in reasonably close conformity to the lines and grades shown on the plans or as established.

All blasting plans shall be approved prior to placing the explosive charges.

Do not bring explosives onto site or use in work without prior written permission from authorities having jurisdiction.

The Contractor is solely responsible for the handling, storage, and use of explosive materials.

The explosives shall be detonated by the propagation or electric method and shall be detonated the same day it is placed.

No explosives shall be stored on the site overnight.

1.5.4 Materials: Dynamite and caps shall be from fresh stock and shall have a maximum strength as specified in the approved blasting plan.

1.5.5 Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.

Operate warning lights as recommended by authorities having jurisdiction.

Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

## 2. PRODUCTS

### 2.1 SOIL MATERIALS:

2.1.1 General: Excavations made at the site for the construction of project facilities will generate unspecified quantities of soil materials. These soils will either be suitable or unsuitable for use as fill in the construction of earth-related portions of the project.

Suitable Materials: Those materials generated from outside excavations that satisfy the specifications for the material for which it is to be used (i.e., compacted silt clay, common borrow, etc.). Specifications for suitable project materials follow.

Unsuitable Materials: Those materials generated from on-site excavations that do not satisfy the specifications for the project materials identified below. Generally these materials will consist of objectionable quantities of vegetation, organic matter, large stones, debris and frozen material.

2.1.2 #67 Stone: Durable, clean angular rock fragments obtained by breaking and crushing rock material, furnished and placed to the lines and grades as shown on the Drawings. Sieve analysis by weight:

| Sieve Designation | % Passing by Weight |
|---|---|
| 1" | 100 |
| 3/4" | 90-100 |
| 3/8" | 20-55 |
| #4 | 0- 10 |
| #8 | 0-5 |
| #200 | 0-0.6 |

2.1.3 Common Borrow (silty sand, sandy silt): Screened material shall be furnished and placed to the lines and dimensions as shown on the Drawings to construct the cell division berm and any base filling requirements. The soil shall not contain particles of rock which will not pass the 1-inch square mesh sieve. The soil shall have greater than 20 passing the U.S. Standard No. 200 Sieve.

## 3. EXECUTION

### 3.1 EXCAVATION:

3.1.1 Unclassified Excavation includes excavation of materials and obstructions encountered to subgrade elevations indicated, regardless of character.

3.1.2 Excavation Classifications: The following classifications of excavation will be made when rock excavation is encountered in work:

3.1.3 Earth Excavation includes excavation of pavements and other obstructions visible on ground surface; underground structures, utilities and other items indicated to be demolished and removed; together with earth and other materials encountered that are not classified as rock or unauthorized excavation.

3.1.4 Rock Excavation:

Rock excavation in trenches and pits includes removal and disposal of materials and obstructions encountered which cannot be excavated with a 1.0 cubic yard (heaped) capacity, 42" wide bucket on track-mounted power excavator equivalent to Caterpillar Model 215, rated at not less than 90HP flywheel power and 30,000 lb. drawbar pull. Trenches in excess of 10'-0" in width and pits in excess of 30'-0" in either length or width are classified as open excavation.

Rock excavation in open excavations includes removal and disposal of materials and obstructions encountered which cannot be dislodged and excavated with modern track-mounted heavy-duty excavating equipment without drilling, blasting or ripping. Rock excavation equipment is defined as Caterpillar Model No. 973 or No. 977K, or equivalent track-mounted loader, rated at not less than 170HP flywheel power and developing 40,000 lb. break-out force (measured in accordance with SAE J732C).

Typical of materials classified as rock are boulders 3 cu. yd. or more in volume, solid rock, rock in ledges, and rock hard cementitious aggregate deposits.

Intermittent drilling, blasting or ripping performed to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation.

Do not perform rock excavation work until material to be excavated has been cross-sectioned and classified and worksheets submitted to the Owner's Representative.

Rock payment lines are limited to the following:

In pipe trenches, 6 inches below invert elevation of pipe and 18 inches wider than inside diameter of pipe, but not less than 3 ft.

In open areas, 24 inches below base grade elevation.

3.1.5 Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Owner's Representative. Unauthorized excavation, as well as remedial work directed by Owner's Representative, shall be at Contractor's expense.

Backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by Owner's Representative.

3.1.6 Additional Excavation: When excavation has reached required subgrade elevations, notify Owner's Representative who will make an inspection of conditions. Do not backfill excavations without notifying Owner's Representative.

If unsuitable bearing materials are encountered at required subgrade elevations, carry excavations deeper and replace excavated material as directed by Owner's Representative.

Removal of unsuitable material and its replacement as directed will be paid on basis of contract conditions relative to changes in work.

3.1.7 Stability of Excavations: Slope sides of excavations to comply with federal and local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated.

Maintain sides and slopes of excavations in safe condition until completion of backfilling.

3.1.8 Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition.

Establish requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction.

Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses.

Provide permanent steel sheet piling or pressure creosoted timber sheet piling wherever subsequent removal of sheet piling might permit lateral movement of soil under adjacent structures. Cut off tops as required and leave permanently in place.

3.1.9 Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

Use appropriate erosion control in temporary ditches, as described in Section 02270, Erosion Control.

3.1.10 Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage. Cover or seed stockpiles when long-term storage indicates the potential for wind or water erosion from the stockpile. Place silt fence around downstream edge of stockpile to prevent transportation of soil.

Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.

Dispose of excess soil material and waste materials as herein specified by Owner's Representative.

3.1.11 Excavation for Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10', and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.

3.1.12 Excavation for Trenches: Dig trenches to the uniform width required for particular item to be installed, sufficiently wide to provide ample working room. Provide a minimum 6" to 9" clearance on both sides of pipe or conduit as indicated on Drawings.

Excavate trenches to depth indicated or required. Carry depth of trenches for piping to establish indicated flow lines and invert elevations.

Where rock or unsuitable material is encountered, carry excavation 6" below required elevation and backfill with a 6" layer of crushed stone or gravel, as approved by Owner's Representative, prior to installation of pipe.

For pipes or conduit 6" or larger in nominal size, tanks and other work indicated to receive subbase, excavate to subbase depth or, if not otherwise indicated, to 6" below bottom of work to be supported.

Grade bottoms of trenches as indicated, notching under pipe bells to provide solid bearing for entire body of pipe.

Do not backfill trenches until tests and inspections have been made and backfilling authorized by Owner's Representative. Use care in backfilling to avoid damage or displacement of pipe systems. Owner's Representative must be notified of any intention to backfill trench or otherwise permanently cover pipe.

3.1.13 Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35° F. (1°C).

3.1.14 Final Grading: Perform grading in accordance with Contract Drawings, in order to obtain subgrade elevations prior to the placement of the geomembrane. During the regrading, the Contractor shall fill voids encountered below the subgrade elevations with on-site materials or materials provided by the Owner.

3.2 COMPACTION:

3.2.1 General: Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated below.

3.2.2 Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture density relationship (cohesive soils) determined in accordance with ASTM D 1557; and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

Pipeline: Compact top 6" of subgrade and each 12" layer of backfill or fill material at 90% maximum density.

Dikes: Compact each 12-inch layer of fill material at 90% maximum density.

Liner Subgrade: Compact top 6" of subgrade at 90 percent maximum density. Maintain these conditions until geomembrane is installed.

3.2.3 Moisture Control: Where subgrade or layer of soil material must be moisture conditioned to meet the allowable range of water content to achieve compaction, uniformly apply water to surface of subgrade, or layer of soil material. Apply water in manner to prevent free water appearing on surface during or subsequent to compaction operations.

Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to a satisfactory value.

3.3 BACKFILL AND FILL:

3.3.1 General: Place acceptable soil material in layers to required subgrade elevations, for each area classification listed below.

In excavations, use satisfactory excavated or borrow material free of frozen material, stones larger than 6 inches in diameter, brush, roots, sod, or other unsuitable material.

Under grassed areas, use satisfactory excavated or borrow material.

Under piping and conduit, use subbase material where subbase is indicated under piping or conduit; shape to fit bottom $90^{o}$ of cylinder.

3.3.2 Backfill excavations as promptly as work permits, but not until completion of the following:

Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.

Inspection by Owner's Representative, testing, approval, and recording locations of underground utilities.

Removal of shoring and bracing, and backfilling of voids with satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure or utilities, or leave in place if required.

Removal of trash and debris.

Permanent or temporary horizontal bracing is in place on horizontally supported walls.

3.3.3 Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip, or break-up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with existing surface.

When existing ground surface has a density less than that specified under "Compaction" for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content, and compact to required depth and percentage of maximum density.

3.3.4 Placement and Compaction: Place backfill and fill materials in layers not more than 12" in loose depth for material compacted by heavy compaction equipment, and not more than 6" in loose depth for material compacted by hand-operated tampers.

Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

Place backfill and fill materials evenly adjacent to structures, piping or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping or conduit to approximately same elevation in each lift.

## 3.4 FIELD QUALITY ASSURANCE

3.4.1 Quality Assurance Testing During Construction: Allow testing service to inspect and approve subgrades and fill layers before further construction work is performed.

Testing shall be as follows:

- o #67 Stone:
  - Grain Size (D422) - 1/1000 cy
- o Common Borrow (silty sand, sandy silt, etc.):
  - Grain Size (D422) - 1/1000 cy
  - Standard Proctor (D1557) - 1/3000 cy
  - Moisture/Density (D2922) - 10/acre/lift

If in opinion of Owner's Representative, based on testing service reports and inspection, subgrade or fills which have been placed are below specified density, provide additional compaction, wetting, drying or removal of material as necessary, and testing at no additional expense.

## 3.5 MAINTENANCE:

3.5.1 Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.

3.5.2 Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn, gravel road, or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.6 DISPOSAL OF EXCESS AND WASTE MATERIALS:

3.6.1 Removal to Designated Areas on Owner's Property: Transport acceptable excess excavated material to designated soil storage areas on Owner's property. Stockpile soil and seed or spread and seed as directed by Owner's Representative.

Transport waste material, including unacceptable excavated material, trash and debris to designated spoil areas on Owner's property and dispose of as directed.

END OF SECTION

SECTION 02261

RIPRAP

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions, apply to work of this Section.

1.02 RELATED WORK SPECIFIED ELSEWHERE:

A. Sitework - General: Section 02000

B. Earthwork: Section 02200

C. Site Dewatering and Erosion Control: Section 02220

1.03 DESCRIPTION

A. Work specified in this Section shall consist of furnishing all labor, materials, and equipment to place a protective covering of riprap on the slopes of embankments, dikes, streambanks, channels, and storm sewer outlets in conformity with the Contract Drawings and as specified herein.

PART 2 - MATERIALS

2.01 TYPE OF STONE: Stones used for riprap shall consist of sound durable rock which will not become disintegrated by exposure to the action of water or weather. Either field stone or rough unhewn quarry stone may be used. Stones shall weigh from 10 lbs to 200 lbs except that when available suitable stones weighing more than 200 lbs may be used. Approximately 50 percent of the stones by volume, shall exceed a unit weight of 90 lbs.

2.02 EXPOSED STONE: The exposed stones for riprap shall be angular and as nearly rectangular in cross-section as practicable. Rounded boulders or cobbles will not be permitted.

2.03 GEOTEXTILE: A woven geotextile conforming to Specification 02272, Geotextiles, paragraph 2.01A, shall be placed along the areas receiving riprap as shown on the Contract Drawings or as directed by the Owner's Representative.

PART 3 - EXECUTION

3.01 PLACEMENT OF RIPRAP: Riprap shall be placed full depth in one operation without special handwork, shall be approximately true to the required slope line and grade and be uniform in appearance. Larger stones shall be placed at the base of the slope. The stones shall be placed on close contact with the longer axis perpendicular to the plane of the slope and so as to stagger joints. The openings between the stones shall be filled with spall, or gravel and rocks securely rammed into place.

END OF SECTION

## SECTION 02270

## EROSION CONTROL

### PART 1 - GENERAL

### 1.1 DESCRIPTION

Work covered by this Section includes the control of erosion, siltation, and sedimentation.

### 1.2 PROJECT REQUIREMENTS

1.2.1 Permits: Comply with all Federal, state and local laws, ordinances, rules and regulations. A permit will be secured by the Owner prior to the work.

1.2.2 Prevention: Take every reasonable precaution and do whatever is necessary to avoid any erosion and to prevent silting of rivers, streams, lakes, reservoirs, impoundment's, and drainage ditches and swales.

1.2.3 Exposure: The exposure of uncompleted cut slopes, embankments, trench excavations, and site graded areas shall be kept as short as possible. Initiate seeding and other erosion control measures on each segment as soon as reasonably possible.

1.2.4 Temporary Protection: Should it become necessary to suspend construction for any length of time, shape all excavated and graded areas in such a manner that runoff will be intercepted and diverted to points where minimal erosion will occur. Provide and maintain temporary erosion and sediment control measures, such as berms, dikes, slope drains, silt stops, and sedimentation basins, until permanent drainage facilities or erosion control features have been completed and are operative.

1.2.5 Handling of Fine Material: Fine material placed or exposed during the work shall be so handled and treated as to minimize the possibility of its reaching any surface waters. Use diversion channels, dikes, sediment traps, or any other effective control measures.

1.2.6 Silt Stops: Provide silt stops wherever erosion control measures may not be totally capable of controlling erosion, such as in drainage channels and where steep slopes may exist.

1.2.7 Special Precautions: Take special precautions in the use of construction equipment to minimize erosion. Do not leave wheel tracks where erosion might begin.

1.2.8 Off-Site Erosion Control: The requirements of this Section also apply to Project-related construction activities away from the Project site, such as at borrow pits, off-site storage areas, and haul and work roads.

1.2.9 Mulching: Mulching shall follow the seeding operation by not more than 24 hours.

1.2.10 Remedial Action: Should any protective measures employed indicate any deficiencies or erosion taking place, immediately provide additional materials or employ different techniques to correct the situation and to prevent subsequent erosion.

1.2.11 Discontinuation: Continue erosion control measures until the permanent measures have been sufficiently established and are capable of controlling erosion on their own.

1.3 QUALITY CONTROL:

Provide at least one person who shall be present at all times during erosion control operations and who shall be thoroughly familiar with the types of materials being installed and the best methods for their installation and who shall direct all work performed under this Section.

Material manufacturers and vendors shall be reputable, qualified firms regularly engaged in producing the required types of materials.

Protect and maintain all areas disturbed by the Work, such that erosion is adequately controlled and silt and sediments are not allowed to flow into any watercourse, onto adjacent properties, or into storm drains.

PART 2 - PRODUCTS

2.1 HAY AND STRAW MULCH:

2.1.1 General: Hay and straw mulches shall be reasonably free from swamp grass, weeds, twigs, debris and other deleterious material, and free from rot, mold, primary noxious weed seeds, and rough or woody materials. Mulches containing mature seed of species which would volunteer and be detrimental to the permanent seeding, or would result in overseeding, or would produce growth which is aesthetically unpleasing, is not permitted.

2.1.2 Hay Mulch: Properly aired native hay, Sudan grass hay, broomsedge hay, legume hay, or similar hay or grass mowings. When air-dried in the loose state, the contents of the representative bale shall lose not more than fifteen (15) percent of the resulting air-dry weight of the bale. Apply at the rate of 2 tons/ac.

2.1.3 Mulch Stabilizers: "Curasol" applied at the rate of 40 gal/ac. or Dow "Mulch Binder" applied at the rate of 45 gal/ac.

2.1.4 Permanent Type Mulch Nets: P300 as manufactured by North American Green, or approved equal.

2.1.5 Temporary Type Mulch Nets: C125 as manufactured by North American Green, or approved equal.

2.2 SEED AND SOD FOR EROSION CONTROL:

2.2.1 For Temporary Control Use annual or perennial ryegrass.

2.2.2 For Permanent Control See Section "Seeding".

2.3 HAY BALES FOR EROSION CONTROL:

Rectangular shaped bales of hay or straw, weighing at least 40 lbs per bale, free from primary noxious weed seeds and rough or woody materials.

2.4 SILT FENCES:

"Envirofence" by Mirafi, Inc. or an approved equal.

PART 3 - EXECUTION

3.1 HAY AND STRAW MULCHING:

3.1.1 Install hay or straw mulch immediately after each area has been properly prepared. When permanent seed or seed for temporary erosion control is shown prior to placing the mulch, place mulch on seeded areas within 24 hours after seeding. Engineer may authorize the blowing of chopped mulch provided that 95% of the mulch fibers will be 6" or more in length and that it can be applied in such a manner that there will be a minimum amount of matting that would retard the growth of plants. Hay mulch should cover the ground enough to shade it, but the mulch should not be so thick that a person standing cannot see the ground through the mulch. Remove matted mulch or branches.

3.1.2 Apply a system of pegs and strings, a chemical stabilizer, or temporary type netting to the mulch, where mild winds may blow the mulch, or when ground slopes exceed 15%, or when otherwise required to maintain the mulch firmly in place. Unless otherwise directed, remove the strings and netting prior to the acceptance of the Work.

3.1.3 Apply temporary type netting over the mulch and take whatever measures are necessary to maintain the mulch firmly in place, where high winds exist, or heavy rainstorms are likely, or where ground surfaces are steep, or where other conditions require.

3.1.4 The use of permanent type netting is not permitted without the prior approval of Engineer, unless otherwise specified.

3.2 HAY BALES AND SILT FENCES:

3.2.1 Provide hay bales or silt fences, as required, for the temporary control of erosion and to stop silt and sediment from reaching surface waters, adjacent properties, or entering catch basins, or damaging the Work.

3.2.2 Stake the hay bales as shown in the details to hold them firmly in place. Use a sufficient number of bales to accommodate runoff without causing any flooding and to adequately store any silt, sediment and debris reaching them (minimum of 1 every 50 feet).

3.2.3 Erect silt fences and bury bottom edge in accordance with the manufacturer's recommended installation instructions. Provide a sufficient length of fence to accommodate runoff without causing any flooding and to adequately store any silt, sediment, and debris reaching it.

3.2.4 Leave hay bales and silt fences in place until permanent erosion control measures have stopped all erosion and siltation, then remove and dispose of properly.

## 3.3 MAINTENANCE

If any temporary erosion and sediment control measures are disturbed, repair them immediately. Check erosion control devices weekly and after any heavy rain storms.

If seed is washed out before germination, repair any damage, refertilize, and reseed.

Maintain mulched and matted areas, silt stops, and other temporary control measures until the permanent control measures are established and no further erosion is likely.

END OF SECTION

# SECTION 02480

# SEEDING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS:

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

### 1.2 DESCRIPTION OF WORK:

All areas disturbed by the construction shall be seeded as specified in this Section.

### 1.3 QUALITY ASSURANCE:

1.3.1 General: Ship seeding materials with certificates of inspection required by governing authorities. Comply with regulations applicable to seeding materials.

1.3.2 Substitutions. If specified seeding material is not obtainable, submit non-availability to Owner's Representative, together with proposal for use of equivalent material.

1.3.3 Analysis and Standards: Package standard products with manufacturer's certified analysis. For other materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists, wherever applicable.

1.3.4 Topsoil: Before delivery of topsoil, furnish Owner's Representative with written statement giving location of properties from which topsoil is to be obtained, names and addresses of owners, depth to be stripped, and crops grown during past 2 years. Onsite soil strippings may be used subject to approval of Owner's Representative.

### 1.4 SUBMITTALS:

1.4.1 Certification: Submit certificates of inspection as required by governmental authorities. Submit other data substantiating that materials comply with specified requirements. Submit other data substantiating that materials comply with specified requirements.

Submit seed vendor's certified statement for each grass seed mixture required, stating botanical and common name, percentage by weight, and percentages of purity, germination, and weed seed for each grass seed species.

1.4.2 Planting Schedule: Seeding will occur between May 15 and September 15. If not, add 35 lbs/acre annual ryegrass to the seeding mixture.

1.5 DELIVERY, STORAGE AND HANDLING:

1.5.1 Packaged Materials: Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

1.6 JOB CONDITIONS:

1.6.1 Proceed with and complete seeding as rapidly as portions of site become available, working within seasonal limitations for work required.

1.6.2 Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Owner's Representative before planting.

1.6.3 Planting Time: Plant or install materials during normal planting seasons. Correlate planting with expected germination periods.

1.7 WARRANTY:

1.7.1 Warranty seeded areas for one full year.

PART 2 - PRODUCTS

2.1 TOPSOIL:

2.1.1 Topsoil (strippings) for landscape work is available at site.

2.2 SOIL AMENDMENTS:

2.2.1 Lime: Natural dolomitic limestone containing not less than 85% of total carbonates with a minimum of 30% magnesium carbonates, ground so that not less than 90% passes a 10-mesh sieve and not less than 50% passes a 100-mesh sieve. Contractor shall apply lime at a rate based on testing of soil performed by Contractor.

2.2.2 Mulch: 3 tons/acre.

2.2.3 Commercial Fertilizer: 1300 lbs/acre (10-10-10 analysis).

2.3 GRASS MATERIALS:

2.3.1 Grass Seed: Provide fresh, clean, new-crop seed complying with tolerance for purity and germination established by Official Seed Analysts of North America. Provide seed mixture composed of grass species, proportions and minimum percentages of purity, germination, and maximum percentage of weed seed, as specified below:

| | |
|---|---|
| Kentucky 31 Fescue | 25 lbs/acre |
| Red Fescue | 40 lbs/acre |
| Kentucky Bluegrass | 25 lbs/acre |
| White Clover | 10 lbs/acre |
| | 100 lbs/acre |

2.4 MISCELLANEOUS LANDSCAPE MATERIALS:

2.4.1 Mulch Binder: Material for mulch binder may be latex based of a type acceptable to the Owner's Representative. Other types of approved mulch binders may be used when authorized.

PART 3 - EXECUTION

3.1 PREPARATION:

3.1.1 Preparation for Planting:

Loosen subgrade of areas to be seeded to a minimum depth of 4". Remove stones over 6" in any dimension and sticks, roots, rubbish and other extraneous matter. Limit preparation to areas which will be planted promptly after preparation.

Spread top soil to minimum depth required to meet lines, grades and elevations shown, after light rolling and natural settlement. Add specified soil amendments and mix thoroughly into upper 4" of topsoil.

Moisten prepared areas before planting if soil is dry. Water thoroughly and allow surface moisture to dry before planting lawns. Do not create a muddy soil condition.

Restore areas to specified condition if eroded or otherwise disturbed after fine grading and prior to planting.

3.2 SEEDING:

3.2.1 Do not use wet seed or seed which is moldy or otherwise damaged in transit or storage.

3.2.2 Sow seed using a spreader or seeding machine. Do not seed or mulch when wind velocity exceeds 5 mi. per hr. Distribute seed evenly over entire area by sowing equal quantity in 2 directions at right angles to each other.

3.2.3 Sow not less than the quantity of seed specified or scheduled.

3.2.4 Rake seed lightly into top 1/8" of soil, roll lightly, and water with a fine spray.

3.2.5 Protect seeded slopes against erosion with erosion netting or other methods acceptable to the Owner's Representative as specified in Section 02270, Erosion Control.

3.2.6 Protect seeded areas against erosion by spreading specified mulch after completion of seeding operations. Spread uniformly to form a continuous blanket not less than 1-1/2" loose measurement over seeded areas.

3.3 HYDROSEEDING:

3.3.1 Mix specified seed, fertilizer and pulverized mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic application.

3.3.2 Apply slurry uniformly to all areas to be seeded. Rate of application as required to obtain specified seed sowing rate.

3.4 CLEANUP AND PROTECTION:

3.4.1 During seeding, keep work area in an orderly condition.

3.4.2 Protect seeded area and materials from damage due to adjacent operations, operations by other contractors and trades and trespassers. Maintain protection during installation and germination periods. Treat, repair or replace damaged work as directed.

3.5 INSPECTION AND ACCEPTANCE:

When seeding is completed, including germination, Owner's Representative will, upon request, make an inspection to determine acceptability.

Seeded areas may be inspected for acceptance in parts agreeable to Owner's Representative, provided work offered for inspection is complete.

Where inspected landscape work does not comply with requirements, replace rejected work and continue maintenance until reinspected by Owner's Representative and found to be acceptable.

END OF SECTION

## SECTION 02730

## PIPING SYSTEMS

1. GENERAL

1.1 RELATED DOCUMENTS:

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 DESCRIPTION OF WORK:

1.2.1 Extent of leachate system work is indicated on drawings and schedules, and by requirements of this section including excavation and backfill required for leachate system.

1.3 QUALITY ASSURANCE:

1.3.1 Manufacturer's Qualifications: Firms regularly engaged in manufacture of products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 SUBMITTALS:

1.4.1 Product Data: Submit manufacturer's technical product data and installation instructions for leachate system materials and products.

1.4.2 Record Drawings: At project closeout, submit record drawings of installed piping and products, including stationing and inverts as requested by the Owner's Representative, and in accordance with requirements of Division 1.

1.4.3 Maintenance Data: Submit maintenance data and parts lists of system materials and products. Include this data, product data, and record drawings in maintenance manual; in accordance with requirements of Division 1.

2. PRODUCTS

2.1 PIPES AND PIPE FITTINGS:

2.1.1 General: Provide pipes of one of the following materials, of weight/class indicated. Provide pipe fittings, cleanouts and all accessories of same material and weight/class as pipes, with joining method as indicated on Drawings.

2.1.2 Perforated High Density Corrugated Polyethylene Pipe: Shall meet the standards of ASTM F 405.

## 3. EXECUTION

### 3.1 INSTALLATION OF PIPE AND FITTINGS:

3.1.1 General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

3.1.2 Inspect piping before installation to detect apparent defects. Mark defective materials with white paint and promptly remove from site.

3.1.3 Lay piping beginning at low point of system, true to grades and alignment indicated, with unbroken continuity of invert.

3.1.4 Place bell ends or groove ends of piping facing upstream.

3.1.5 Install gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements.

3.1.6 HDPE Pipe: Install pipe using manufacturer's recommended method unless otherwise indicated.

3.1.7 Cleaning Pipe: Clear interior of piping of dirt and other superfluous material as work progresses. Maintain swab or drag in line and pull past each joint as it is completed.

In large, accessible piping, brushes and brooms may be used for cleaning.

Place plugs in ends of uncompleted conduit at end of day or whenever work stops.

Flush lines between manholes if required to remove collected debris.

3.1.8 Joint Adapters: Make joints between different types of pipe with standard manufactured adapters and fittings intended for that purpose.

3.1.9 Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.

Make inspections after lines between manholes, or manhole locations, have been installed and approximately 2-ft of backfill is in place, and again at completion of project.

If inspection indicates poor alignment, debris, displaced pipe, infiltration, or other defects, correct such defects, and reinspect.

### 3.2 BACKFILLING:

3.3.1 General: Conduct backfilling operations of open-cut trenches closely following laying, jointing, and bedding or pipe, and after initial inspection and testing are completed.

END OF SECTION

# SECTION 02731

# GEOTEXTILES

## 1. GENERAL

### 1.1 RELATED DOCUMENTS

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of section.

### 1.2 DESCRIPTION OF WORK

Extent of geotextile work is indicated on drawings and schedules, and by requirements of this section.

### 1.3 QUALIFICATIONS AND WARRANTIES

1.3.1 Manufacturer's Qualifications: Firms regularly engaged in manufacture of products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.3.2 Installer's Qualifications: Firms regularly engaged in installation of products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

### 1.4 QUALITY CONTROL DOCUMENTATION

1.4.1 Product Data: Prior to the installation of any geotextile, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. Written certification that minimum average roll values given in the specification are guaranteed by the Manufacturer.

2. For non-woven geotextiles, written certification that the Manufacturer has continuously inspected the geotextile for the presence of needles and found the geotextile to be needle free.

3. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control testes. At a minimum, results shall be given for:

a. Mass per unit area
b. Grab strength
c. Trapezoidal tear strength
d. Burst strength
e. Puncture strength
f. Apparent Opening Size

Quality control tests shall be performed in accordance with the test methods specified in the project specifications for at least every 100,000 $ft^2$ of geotextile produced.

The Manufacturer shall identify all rolls of geotextiles with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

1.4.2 Product Review: The Owner's Representative shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum average roll properties meet the project specifications.

## 2. PRODUCTS

### 2.1 GEOTEXTILE:

2.1.1 General: Provide geotextiles as indicated on Drawings.

2.1.2 Woven Geotextile: The geotextile used in construction of riprap ditches and/or riprap spillways shall be Mirafi 700X, Amoco 1199, as manufactured by Nicolon Mirafi group and

Amoco Fabrics and Fibers Company, respectively, or an approved equal except as shown on the contract drawings.

| Test Method | Minimum Permissible Value |
|---|---|
| Puncture (ASTM D 4833-88) | 135 lb |
| Trapezoidal tear strength (ASTM D-4533) | 100x60 lbs |
| Grab tensile/elongation (ASTM D-4632-91) | 370x250/15% |
| Mullen burst strength (ASTM D-3786) | 480 psi |
| Apparent open size (AOS) (ASTM D-4751) | 70 U.S. Standard sieve |
| Permittivity (ASTM D-4491-92) | 18 gal/min/ft$^2$ |

2.1.3 Non-Woven Geotextile: 6 oz/sy - The geotextile attached to each side of the geonet for Areas F and G shall be Amoco 4506, or meet the minimum requirements listed below:

| PROPERTY | TEST PROCEDURE | MINIMUM VALUE(1) |
|---|---|---|
| Weight | ASTM D 5261 | 6 oz/sy |
| Grab Strength | ASTM D 4632 | 150 lbs |
| Tear Strength | ASTM D 4533 | 65 lbs |
| Mullen Burst | ASTM D 3786 | 350 psi |
| Puncture Resistance | ASTM D 4833 | 90 lbs |
| AOS | ASTM D 4751 | 70 U.S Sieve |

(1) Values in weaker principle direction. All minimum values represent minimum average roll values (i.e. test results from any sampled roll in a lot, tested in accordance with ASTM D 4759-88 shall meet or exceed the minimum values listed.)

2.1.4 Non-Woven Geotextile: 8 oz/sy - The geotextile attached to each side of the geonet for Area H shall be Amoco 4508, or meet the minimum requirements listed below:

| PROPERTY | TEST PROCEDURE | MINIMUM VALUE[1] |
|---|---|---|
| Weight | ASTM D 5261 | 8 oz/sy |
| Grab Strength | ASTM D 4632 | 203 lbs |
| Tear Strength | ASTM D 4533 | 80 lbs |
| Mullen Burst | ASTM D 3786 | 450 psi |
| Puncture Resistance | ASTM D 4833 | 130 lbs |
| AOS | ASTM D 4751 | 100 U.S Sieve |

## 3.0 QUALITY ASSURANCE

### 3.1 GEOTEXTILE DEPLOYMENT

During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions. Geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings. Wrappings shall be removed shortly before deployment.

The Owner's Representative shall observe rolls upon delivery at the site and any deviation from the above requirements shall be reported to the Project Manager.

The Installer shall handle all geotextiles in such a manner as to assure they are not damaged in any way, and the following shall be complied with:

1. On slopes, the geotextiles shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geotextile sheet in tension.

2. In the presence of wind, all geotextiles shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Geotextiles shall be cut using a geotextile cutter (hook blade) only. If in place, special care shall be taken to protect other materials from damage which could be caused by the cutting of the geotextiles.

4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.

5. During placement of geotextiles, care shall be taken not to entrap, in or beneath the geotextile, stones, excessive dust, or moisture that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.

6. A visual examination of the geotextile shall be carried out over the entire surface, after installation, to assure that no potentially harmful foreign objects, such as needles, are present.

## 3.2 SEAMING PROCEDURES

On slopes steeper than 10(horizontal):1(vertical), all geotextiles shall be continuously sewn (i.e. spot sewing is not allowed). Geotextiles shall be overlapped a minimum of 3 inches (75 mm) prior to seaming. In general, no horizontal seams shall be allowed on sideslopes (i.e. seams shall be along, not across, the slope), except as part of a patch.

On bottoms and slopes shallower than 10 (horizontal):1 (vertical), geotextiles shall be seamed as indicated above (preferred), or thermally bonded with the written approval of the Owner's Representative.

The Installer shall pay particular attention at seams to assure that no earth cover material could be inadvertently inserted beneath the geotextile.

Any sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile.

## 3.3 DEFECTS AND REPAIRS

Any holes or tears in the geotextile shall be repaired as follows:

On slopes, a patch made from the same geotextile shall be sewn into place in accordance with the project specifications. Should any tear exceed 10 percent of the width of the roll, that roll shall be removed from the slope and replaced.

Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile.

The Owner's Representative shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

## 3.4 GEOTEXTILE PROTECTION

All soil materials located on top of a geotextile shall be deployed in such a manner as to assure:

1. The geotextile and underlying lining materials are not damaged.

2. Minimal slippage of the geotextile on underlying layers occurs.

3. No excess tensile stresses occur in the geotextile.

Unless otherwise specified by the Owner's Representative, all lifts of soil material shall be in conformance with the guidelines given in Section 02200 and 02771-4.7.1.

END OF SECTION

# SECTION 02741

# GEONETS

## 1. GENERAL

### 1.1 RELATED DOCUMENTS

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of section.

### 1.2 DESCRIPTION OF WORK

Extent of geonet work is indicated on drawings and schedules, and by requirements of this section.

### 1.3 QUALIFICATIONS AND WARRANTIES

1.3.1 Manufacturer's Qualifications: Firms regularly engaged in manufacture of products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.3.2 Installer's Qualifications: Firms regularly engaged in installation of products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

### 1.4 QUALITY CONTROL DOCUMENTATION

1.4.1 Product Data: Prior to the installation of any geonet, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. The origin (resin supplier's name and resin production plant), identification (brand name and number), and production date of the resin.

2. Copies of the quality control certificates issued by the resin supplier.

3. Reports on tests conducted by the Manufacturer to verify that the quality of the resin used to manufacture the geonet meets the specifications.

4. Reports on quality control tests conducted by the Manufacturer to verify that the geonet manufactured for the project meets the project specifications.

5. A statement indicating that the amount of reclaimed polymer added to the resin during manufacturing was done with appropriate cleanliness and does not exceed 2 percent by weight.

6. A list of the materials which comprise the geonet, expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.

7. A specification for the geonet which includes all properties contained in the specifications measured using the appropriate test methods.

8. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.

9. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control tests. At a minimum, results shall be given for:

    a. Density
    b. Tensile strength
    c. Transmissivity
    d. Carbon black content

    Quality control tests shall be performed in accordance with the test methods specified in the specifications, for every 40,000 $ft^2$ (4,000 $m^2$) of geonet produced.

The Manufacturer shall identify all rolls of geonet with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
5. Roll dimensions

The Owner's Representative shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The Owner's Representative shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum properties meet the specifications.

## 2. PRODUCTS

### 2.1 GEONET

2.1.1 General: Provide geonet as indicated on Drawings.

2.1.2 Geonet: The geonet within the drainage system shall be GSE Fabrinet or meet the minimum requirements listed below:

| Property | Qualifier | Test Method | Spec. Value | Unit |
|---|---|---|---|---|
| Density | Minimum | ASTM D 1505 | 0.93 | g/cc |
| Carbon Black | Range | ASTM D 1603 | 2 - 3 | percentage |
| Tensile Strength | Minimum | ASTM D 751 | 50 MD/25XD | ppi |
| Transmissivity | Minimum | ASTM D 4716 | $3x10^{-4}$ * | cm/sec |

Notes:

MD machine direction
XD transverse direction
* At 0.02 hydraulic gradient, 20,000 psf compressive load

## 3. QUALITY ASSURANCE

### 3.1 GEONET DEPLOYMENT

During shipment and storage, the geonet shall be protected from inundation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

The Owner's Representative shall observe rolls upon delivery at the site and any deviation from the above requirements shall be reported to the Project Manager.

The Installer shall handle all geonet in such a manner as to assure they are not damaged in any way, and the following shall be complied with:

1. On slopes, the geonet shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geonet sheet in tension.

2. In the presence of wind, all geonet shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Geonets shall be cut using a hook blade only. If in place, special care shall be taken to protect other materials from damage which could be caused by the cutting of the geonets.

4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geonet.

5. During placement of geonets, care shall be taken not to entrap, in or beneath the geonet, stones, excessive dust, or moisture that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.

6. A visual examination of the geonet shall be carried out over the entire surface, after installation, to assure that no potentially harmful foreign objects are present.

The independent laboratory shall note any noncompliance and report it to the Project Manager.

## 3.2 SEAMING PROCEDURES

Geonets shall be overlapped a minimum of 4 inches (75 mm) prior to tying. In general, no horizontal seams shall be allowed on sideslopes (i.e. seams shall be along, not across, the slope), except as part of a patch.

## 3.3 SEAMS AND OVERLAPS

Adjacent geonet shall be joined according to construction drawings and specifications. At a minimum, the following requirements shall be met:

1. Adjacent rolls shall be overlapped by at least 4 inches (100 mm).

2. Overlaps shall be secured by tying.

3. Tying can be achieved by plastic fasteners or polymer braid. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

4. Tying shall be every 5 feet (1.5 m) along the slope, every 6 inches (0.15 m) in the anchor trench, and every 6 inches (0.15 m) along end-to-end seams on the base of the landfill.

5. In general, no horizontal seams shall be allowed on sideslopes.

The Owner's Representative shall note any noncompliance and report it to the Project Manager.

## 3.4 DEFECTS AND REPAIRS

Any holes or tears in the geonet shall be repaired by placing a patch extending 1 foot (0.3 m) beyond the edges of the hole or tear. The patch shall be secured to the original geonet by tying every 6 inches (0.15 m). Tying devices shall be as indicated in Section 3.4. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area shall be repaired as follows:

1. On the base of the landfill, the damaged area shall be cut out and the two portions of the geonet shall be joined as indicated in Section 3.4.

2. On sideslopes, the damaged geonet shall be removed and replaced.

## 3.5 GEONET PROTECTION

Soil should never be placed in direct contact with geonet. Soil materials near the geonet shall be placed in such a manner as to assure:

1. The geonet and underlying lining materials are not damaged.

2. Minimal slippage of the geonet on underlying layers occurs.

3. No excess tensile stresses occur in the geonet.

Unless otherwise specified by the Designer, all lifts of soil material shall be in conformance with the guidelines given in Section 02200 and 02771-4.7.1.

Any noncompliance shall be noted by the Owner's Representative and reported to the Project Manager.

END OF SECTION

SECTION 02771

GEOMEMBRANE LINER (POLYVINYL CHLORIDE (PVC))

## 1. GENERAL

### 1.1 RELATED DOCUMENTS

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of section.

### 1.2 DESCRIPTION OF WORK

Extent of flexible membrane lining work is shown on drawings.

Refer to other Division-2 sections for earthwork related to lining work.

### 1.3 QUALITY ASSURANCE, QUALIFICATIONS, AND WARRANTIES

1.3.1 Manufacturer's Experience: The manufacturer supplying the membrane shall satisfactorily demonstrate previous experience by letter of certification. Certification shall indicate that the manufacturer has produced, and has in service in similar applications for a period of not less than one (1) year, at least two (2) million sq ft of PVC material meeting these Specifications.

1.3.2 Installer's Experience: The Installer proposing to install the lining shall satisfactorily demonstrate previous experience by letter of certification. Certification shall indicate the Installer's successful past installation of at least 2,000,000 sq ft of PVC geomembrane.

Installation shall be performed under the direction of a single installation supervisor who shall remain on site and be in responsible charge throughout the liner installation, including subgrade acceptance, liner layout, seaming, testing and repairs, and all other activities contracted for with the Installer. The installation supervisor shall have supervised the installation of at least 2,000,000 sf of PVC geomembrane. Actual seaming shall be performed under the direction of a master seamer who may be the same person as the installation supervisor, and who has a minimum of 1,000,000 sf PVC geomembrane seaming experience using the same type of seaming apparatus as that specified in this project. The installation supervisor or master seamer must be on site whenever seaming is being performed.

1.3.3 Manufacturer's Guarantee: The manufacturer of the membrane liner shall enter into agreement with the Owner guaranteeing the membrane as follows:

The manufacturer warrants the PVC liner which is manufactured, sold as first quality, and installed with technical assistance and/or by an approved installation contractor to be (1) furnished free of manufacturing defects in workmanship or material for a period of one year from the time of delivery with the basis for judgment of defects being the applicable product specifications in effect at the time the order was placed unless modified by mutual written agreement; (2) shall not develop cracks/holes which go completely through the membrane due to the effects of normal service for a period of twenty (20) years from the date of delivery. "Normal service" does not include physical damage caused by acts of God, casualty, or catastrophe such as (but not limited to) earthquakes, fire, explosion, floods, lightning, piercing hail, tornadoes, corrosive air pollution, mechanical abuse by machinery, equipment, people or animals, or excessive flexures, pressures or stress from any source other than faulty installation, and (3) immune to chemical attack and degradation by chemicals, specified in the manufacturer's literature, as compatible with, and as not having an adverse effect on the membrane; and (4) immune to chemicals tested by the manufacturer for the Owner.

Should defects or weathering degradation within the scope of the above warranty occur, the manufacturer shall refund to the purchaser-user the pro-rata part for the unexpired term of the warranty of the purchaser-user's original cost of such product, or will supply repair or replacement materials at the then-current price. In the event the manufacturer supplies repair or replacement materials, against the then-current price, the manufacturer will credit the lesser of (1) the pro-rata part of the original sales price of the material so repaired or replaced for the unelapsed period of the warranty, or (2) the pro-rata part of the then-current price of the material so repaired or replaced to the unelapsed period of the warranty. The warranty shall continue in effect on the repaired or replaced material for the unelapsed term of the original warranty. To enable the manufacturer's technical staff to properly determine the cause of any alleged defect and to take appropriate steps to effect timely corrective measures if such defect is within the warranty, any claim for alleged breach of warranty will be made and presented in writing to manufacturer and the installing Contractor within thirty (30) days after the alleged defect was first noticed.

## 1.4 QUALITY CONTROL DOCUMENTATION

1.4.1 Product Data: Prior to the installation of any geomembrane, the manufacturer, fabricator, or installer shall provide the Owner's Representative with the following information:

1. Copies of the quality control certificates issued by the resin supplier.

2. Reports on quality control tests conducted by the Manufacturer to verify that the geomembrane manufactured for the project meets the project specifications.

3. A list of the materials which comprise the geomembrane, expressed in the following categories as percent by weight: polyvinyl chloride resin, plasticizer(s), fillers, and additives.

4. Reports on quality control tests conducted by the fabricator to verify that the geomembrane fabricated for the project meets the project specifications.

5. Written certification that minimum values given in the specification are guaranteed by the manufacturer or fabricator.

6. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, sampling procedures, and results of quality control tests. At a minimum, results shall be given for:

   a. Density
   b. Thickness
   c. Tensile properties

   These quality control tests shall be performed in accordance with the test methods specified in the specifications.

The Manufacturer shall identify all rolls of geomembrane with the following:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Roll number
5. Roll dimensions

The Fabricator shall identify all panels of geomembrane with the following:

1. Fabricator's name
2. Product identification
3. Thickness
4. Roll numbers included in the panel
5. Panel dimensions and placement identifier

1.4.2 Product Review: The Owner's Representative shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided for all rolls and panels, and that each certificate identifies the rolls related to it.

4. Panel packages are appropriately labeled.

5. Certified minimum properties meet the specifications.

## 2. PRODUCTS

### 2.1 POLYVINYL CHLORIDE (PVC) MEMBRANE

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

2.1.2 Physical Characteristics: The PVC materials shall have the following physical characteristics:

| Property | Qualifier | Test Method | Spec Value | Unit |
|---|---|---|---|---|
| PVC GEOMEMBRANE PROPERTIES | | | | |
| Thickness | Nominal | - | 40 | mils |
| Thickness | minimum | ASTM D 1593, (para.8.1.3) | 38 | mils |
| Specific Gravity | minimum | ASTM D 792 Method A | 1.2 | g/cc |
| Tensile Properties | | | | |
| Break strength | minimum | ASTM D 882 Method A or B | 92 | lbs/in. |
| Break elongation | minimum | ASTM D 882 Method A or B | 350 | percent |
| Modulus @ 100% Elongation | minimum | ASTM D 882 Method A or B | 36 | lbs/in. |
| Tear Resistance | minimum | ASTM D 1004, Die C | 10 | lbs |
| Low Temperature | maximum | ASTM D 1790 | -29 | degrees C |
| Dimensional Stability | maximum change | ASTM D 1204[2] | 5 | percent |
| Water Extraction | maximum | ASTM D 3083[1] | -0.35 | percent |
| Volatile Loss | maximum | ASTM D 1203 Method A | 0.5 | percent |
| Resistance to Soil Burial | | | | |
| Break | maximum | ASTM D 3083[1] | 5 | percent |
| Elongation @ Break | maximum | ASTM D 3083[1] | 20 | percent |
| Modulus @ 100% Elongation | maximum | ASTM D 3083[1] | 20 | percent |
| Hydrostatic Resistance | minimum | ASTM D 751 Method A | 82 | lbs/sq in. |
| PVC SEAM PROPERTIES | | | | |
| Thickness | minimum | - | 38 | mils |
| Bonded Seam Strength | minimum | ASTM D 3083[1,3] | 74 | lbs/in. |
| Peel Adhesion | | | | |
| Hot Wedge | minimum | ASTM D 3083[1,3] | 10 | lbs/in. |
| Solvent | minimum | ASTM D 3083[1,3] | 10 | lbs/in. |

Notes:
1. As modified in Annex A.
2. 100°C for 15 minutes.
3. For shear tests, the sheet shall yield before failure of the seam. For peel adhesion, seam separation shall not extend more than 10% into the seam. For either test, testing shall be discontinued when the sample has visually yielded.

The geomembrane shall be produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter, and shall not have striations, roughness, pinholes or bubbles on the surface.

2.1.3 Documentation: Prior to delivery of the geomembrane to the job site, the Installer shall be required to provide the Owner with a written certification that the product delivered was extruded from the specified resin. The manufacturer shall provide quality control certificates for each batch of resin and each shift's production of geomembrane, and shall follow the quality control testing program as described in Section 1.4. These quality control certificates shall be signed by responsible parties employed by the Manufacturer, and shall be supplied to the Owner. No geomembrane will be permitted to be delivered until the Owner has in his possession such certification.

2.1.4 Panel and Roll Identification: Each panel and roll shall have permanently affixed the following information: name of manufacturer/fabricator; date of manufacture/fabrication; resin batch code; thickness of the material; roll number(s); roll length; and roll width.

## 2.2 MISCELLANEOUS MATERIALS

2.2.1 Pipe Boots, Vents, and Patches: All such devices shall be of the same material as the lining or a compatible approved equal.

2.2.2 Mechanical Fastenings: Mechanical fastenings shall be of the material, size, and type as detailed on the plans or approved shop drawings.

# 3. QUALITY ASSURANCE

## 3.1 CONFORMANCE TESTING

Upon delivery of the panels of geomembrane, the Owner's Representative shall assure that one (1) conformance test sample is obtained from the geomembrane. The sample shall then be forwarded to an independent laboratory for testing to assure conformance to the specifications.

The following conformance tests shall be conducted:

1. Density
2. Thickness
3. Tensile characteristics

These conformance tests shall be performance in accordance with the test methods specified in the specifications.

3.1.1 Sampling Procedures: The panel to be sampled shall be selected by the Owner's Representative. The sample shall be

taken across the entire width of a roll and shall not include the first 3 feet (1 m). Unless otherwise specified, samples shall be 3 feet (1 m) long by the roll width. The Owner's Representative shall mark the machine direction on the sample with an arrow.

3.1.2 Test Results. All conformance test results shall be reviewed and accepted or rejected by the Owner's Representative prior to the deployment of the geomembrane.

The Owner's Representative shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The Owner's Representative shall be responsible for checking that all test results meet or exceed the property values listed in Section 2.1.2.

## 4. EXECUTION

### 4.1 SUBGRADE PREPARATION

4.1.1 Surface Preparation: The earthwork contractor shall be responsible for preparing the supporting soil for geomembrane placement. The Owner's Representative shall coordinate the work of the earthwork contractor and the Installer so that the requirements of the specification are met.

Before the geomembrane installation begins, the Owner's Representative shall verify that:

1. The surface to be lined has been rolled, compacted, or handworked so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade.

2. The surface of the supporting soil does not contain stones which may be damaging to the geomembrane.

3. There is no area excessively softened by high water content.

4. There is no area where the surface of the soil contains desiccation cracks with dimensions exceeding those allowed by the project specifications.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. A certificate of acceptance shall be given by the Installer to the Owner's Representative prior to commencement of geomembrane deployment in the area under consideration.

After the supporting soil has been accepted by the Installer, it is the Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work.

## 4.2 GEOMEMBRANE DEPLOYMENT

4.2.1 Panel Nomenclature: A field panel is defined as a unit of geomembrane which is to be seamed in the field.

It shall be the responsibility of the Installer/Fabricator to assure that each field panel is given an identification code (number or letter-number) consistent with the approved layout plan. This field panel identification code shall be as simple and logical as possible. The Installer/Fabricator shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

The Owner's Representative shall verify that field panels are installed at the locations indicated on the Installer's layout plan, as approved by the Owner's Representative.

4.2.2 Panel Deployment Procedure: The Owner's Representative shall review the panel deployment progress of the Installer (keeping in mind issues relating to wind, rain, and other site-specific conditions). The Owner's Representative shall verify that the condition of the supporting soil does not change detrimentally during installation.

The Owner's Representative shall record the identification code, location, and date of installation of each field panel.

4.2.3 Deployment Weather Conditions: Geomembrane deployment shall not proceed at an ambient temperature below 32°F (0°C) or above 104°F (40°C) unless otherwise authorized, in writing, by the Owner's Representative. Geomembrane placement shall not be performed during any precipitation, in the presence of excessive moisture (e.g. fog, dew), in an area of ponded water, or in the presence of excessive winds. Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment.

The Owner's Representative shall verify that the above conditions are fulfilled. Ambient temperature shall be measured by the Owner's Representative in the area in which the panels are to be deployed. The Owner's Representative shall inform the Installer of any weather related problems which may not allow geomembrane placement to proceed.

4.2.4 Method of Deployment: Before the geomembrane is handled on site, the Owner's Representative shall verify that handling equipment to be used on the site is adequate and does not pose risk of damage to the geomembrane. During handling, the Owner's Representative shall observe and verify that the Installer's personnel handle the geomembrane with care.

The Owner's Representative shall verify the following:

1. Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.

2. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement.

3. All personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities which could damage the geomembrane.

4. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil.

5. The method used to place the panels minimized wrinkles (especially differential wrinkles between adjacent panels).

6. Adequate temporary loading and/or anchoring (e.g. sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind. In case of high winds, continuous loading, e.g. by sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels.

7. Direct contact with the geomembrane is minimized, and the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

The Owner's Representative shall inform the Installer if the above conditions are not fulfilled.

4.2.5 Damage and Defects: Upon delivery to the site, the Owner's Representative shall conduct a surface observation of all panels for defects and for damage. This inspection shall be conducted without unfolding panels unless defects or damages are found or suspected. The Owner's Representative shall advise the Installer, in writing, of any panels or portions of panels which should be rejected and removed from the site because they have severe flaws, and/or minor repairable flaws.

The Owner's Representative shall inspect each panel, after placement and prior to seaming, for damage and/or defects. The Owner's Representative shall advise the Installer which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the Owner's Representative. Repairs shall be made using procedures described in Section 4.6.

4.2.6 Writing on the Liner: To avoid confusion, the Installer and the Owner's Representative shall each use different colored markers that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane.

## 4.3 FIELD SEAMING

4.3.1 Seam Layout: Before installation begins, the Installer must provide the Owner's Representative with a panel layout drawing, i.e. a drawing of the facility to be lined showing all expected seams. The Owner's Representative shall review the panel layout drawing and verify that it is consistent with accepted state-of-practice. No panels may be seamed without the written approval of the panel layout drawing by the Owner's Representative. In addition, panels not specifically shown on the panel layout drawing may not be used without the Owner's Representative's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e. oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 feet (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized by the Owner's Representative.

A seam numbering system compatible with the panel numbering system shall be used by the Owner's Representative.

4.3.2 Accepted Seaming Methods: Hot-wedge welding will be the preferred method of seaming panels. Solvent welding will be allowed on patches, pipe boots, and in specialty areas. Proposed alternate processes shall be documented and submitted by the Installer to the Owner's Representative for approval.

4.3.2.1 Seaming Process: The Owner's Representative shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Installer.

The Owner's Representative shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus decided upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

4. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage.

5. The geomembrane is protected from damage in heavily trafficked areas.

6. A movable protective layer is used as required by the Installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and prevent debris from collecting around the pressure rollers.

7. In general, the geomembrane panels are aligned to have a nominal overlap of 5 inches (125 mm) for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

4.3.3 Seam Preparation: The Owner's Representative shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the Owner's Representative must assure that the process is completed according to the Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane. The Owner's Representative shall also verify that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

4.3.4 Trial Seams: Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours. Trial seams shall be made under the same conditions as actual seams.

The trial seam sample shall be at least 5 feet (1.0 m) long by 1 foot (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section 4.3.2.

Two specimens shall be cut from the sample with a 1 inch (25 mm) wide die. The specimens shall be cut by the Installer at locations selected randomly along the trial seam sample by the Owner's Representative. The specimens shall be tested in peel using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial welds are achieved. The Owner's Representative shall observe all trial seam procedures.

4.3.5 General Seaming Procedures: During general seaming, the Owner's Representative shall be cognizant of the following:

1. For fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture buildup between the sheets to be welded and prevent debris from collecting around the pressure rollers.

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

3. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve ficiencies are corrected and two consecutive successful trial welds are achieved. The Owner's Representative shall observe all trial seam procedures.

4.3.5 General Seaming Procedures: During general seaming, the Owner's Representative shall be cognizant of the following:

1. For fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture buildup between the sheets to be welded and prevent debris from collecting around the pressure rollers.

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

3. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches (150 mm) beyond the cut in all directions.

4. Seaming shall e Owner's Representative shall verify that these weather conditions are fulfilled and notify the Installer in writing if they are not. Ambient temperature shall be measured by the Owner's Representative in the area in which the panels are to be placed and decide if the installation is to be stopped or special procedures used.

4.3.6.2 Cold Weather Conditions: To assure a quality installation, if seaming is conducted when the ambient temperature is below 32°F (0°C), the following conditions must be met:

1. Geomembrane surface temperatures shall be determined by the Owner's Representative at intervals of at least once per 100 foot of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32°F (0°C).

2. Preheating may be waived by the Owner's Representative, if the Installer demonstrates to the Owner's Representative's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the Owner's Representative shall inspect all areas of geomembrane that have been preheated by a hot air device prior to seaming, to assure that they have not been overheated.

4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.

5. All preheating devices shall be approved prior to use by the Owner's Representative.

6. Additional destructive tests (as described in Section 4.5) shall be taken at an interval between 500 feet and 250 feet of seam length, at the discretion of the Owner's Representative.

7. Sheet grinding may be performed before preheating, if applicable.

8. Trial seaming, as described in Section 4.3.4, shall be conducted under the same ambient temperature and preheating conditions as the actual seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 5°F from the initial trial seam test conditions.

4.3.6.3 Warm Weather Conditions: At ambient temperatures above 104°F, no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the Owner's Representative that geomembrane seam quality is not compromised.

Trial seaming, as described in Section 4.3.4, shall be conducted under the same ambient temperature conditions as the actual seams.

At the option of the Owner's Representative, additional destructive tests (as described in Section 4.5) may be required for any suspect areas.

## 4.4 NONDESTRUCTIVE SEAM TESTING

4.4.1 Concept: The Installer shall nondestructively test all field seams over their full length using an air lance, air pressure test (for double fusion seams only), or other approved method. Air pressure testing is described in Section 4.4.3. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantitative information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

For all seams, the Owner's Representative shall:

1. Observe nondestructive testing procedures.

2. Record location, data, test unit number, name of tester, and outcome of all testing.

3. Inform the Installer of any required repairs.

4.4.3 Air Pressure Testing: The following procedures are applicable to double fusion welding which produces a double seam with an enclosed space.

1. The equipment shall consist of the following:

   a. An air pump (manual or motor driven), equipped with pressure gauge capable of generating and sustaining a pressure between 20 and 30 psi (160 and 200 kPa) and mounted on a cushion to protect the geomembrane.

   b. A rubber hose with fittings and connections.

   c. A sharp hollow needle, or other approved pressure feed device.

2. The following procedures shall be followed:

   a. Seal both ends of the seam to be tested.

   b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.

c. Insert a protective cushion between the air pump and the geomembrane.

d. Energize the air pump to a pressure between 20 and 30 psi (160 and 200 kPa), close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for at least 2 minutes.

e. If loss of pressure exceeds 4 psi (30 kPa) or does not stabilize, locate faulty area and repair in accordance with Section 4.6.

f. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seal the cut end of the air channel.

g. Remove needle or other approved pressure feed device and seal.

4.4.4 Test Failure Procedures: The Installer shall complete any required repairs in accordance with Section 4.6. For repairs, the Owner's Representative shall:

1. Observe the repair and testing of the repair.

2. Mark on the geomembrane that the repair has been made.

3. Document the repair procedures and test results.

4.5 DESTRUCTIVE SEAM TESTING

4.5.1 Concept: Destructive seam tests shall be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

4.5.2 Location and Frequency: The Owner's Representative shall select locations where seam samples will be cut out for laboratory testing. Those locations shall be established as follows:

1. A minimum frequency of one test location per 500 feet (150 m) of seam length performed by each welder. This minimum frequency is to be determined as an average taken throughout the entire facility.

2. Test locations shall be determined during seaming at the Owner's Representative's discretion. Selection of such locations may be prompted by suspicion of overheating, contamination, offset welds, or any other potential cause of imperfect welding.

The Installer shall not be informed in advance of the locations where the seam samples will be taken.

4.5.3 Sampling Procedures: Samples shall be cut by the Installer at locations chosen by the Owner's Representative as the seaming progresses so that laboratory test results are available before the geomembrane is covered by another material. The Owner's Representative shall:

1. Observe sample cutting.

2. Assign a number to each sample, and mark it accordingly.

3. Record sample location on layout drawing.

4. Record reason for taking the sample at this location (e.g. statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Section 4.6. The continuity of the new seams in the repaired area shall be tested according to Section 4.4.

4.5.4 Sample Dimensions: The sample for testing shall be 12 inches (0.3 m) wide by 42 inches (1.1 m) long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

1. One portion to the Installer for optional laboratory testing, 12 inches x 12 inches (0.3 m x 0.3 m).

2. One portion for field laboratory testing, 12 inches x 18 inches (0.3 m x 0.5 m) and

3. One portion to the Owner's Representative for archive storage, 12 inches x 12 inches (0.3 m x 0.3 m).

Final determination of the sample sizes shall be made at the pre-construction meeting.

4.5.5 Field Laboratory Testing: The coupons, 1 inch (25 mm) wide strips, shall be tested in the field using a tensiometer for peel, shear, and thickness, and shall not fail according to the criteria in Section 2.1.3. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. If it fails, the seam should be repaired in accordance with Section 4.6. Final judgment regarding seam acceptability, based on the failure criteria, rests with the Owner's Representative.

The Owner's Representative shall witness all field tests and mark all samples and portions with their number. The Owner's

Representative shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description, and attach a copy to each sample portion.

4.5.6 Destructive Test Failure Procedures: The following procedures shall apply whenever a sample fails a destructive test. The Installer has two options:

1. The Installer can repair the seam between any two passing test locations.

2. The Installer can trace the welding path to an intermediate location (at 10 feet (3 m) minimum from the point of the failed test in each direction) and take a sample with a 1 inch (25 mm) wide die for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these field laboratory samples pass the tests, then the seam is repaired between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be repaired.

All acceptable repaired seams shall be bound by two locations from which samples passing field laboratory destructive tests have been taken. Passing laboratory destructive tests of trial seam samples taken as indicated in Section 4.3.4 may be used as a boundary for the failing seam. In cases exceeding 150 feet (50 m) of repaired seam, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Repairs shall be made in accordance with Section 4.6.

The Owner's Representative shall document all actions taken in conjunction with destructive test failures.

## 4.6 DEFECTS AND REPAIRS

4.6.1 Identification: All seams and non-seam areas of the geomembrane shall be examined by the Owner's Representative for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be cleaned by the Installer if the amount of dust or mud inhibits examination.

4.6.2 Evaluation. Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in Section 4.5 as appropriate. Each location which fails the nondestructive testing shall be marked by the Owner's Representative and repaired by the Installer. Work shall not proceed with any materials which will cover locations which have

been repaired until appropriate nondestructive and laboratory test results with passing values are available.

4.6.3 Repair Procedures: Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Installer and Owner's Representative.

1. The repair procedures available include:

   a. Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.

   b. Spot welding or seaming, used to repair small tears, pinholes, or other minor, localized flaws.

   c. Capping, used to repair large lengths of failed seams.

   d. Extrusion welding the flap, used to repair areas of inadequate fusion seams, which have an exposed edge. Repairs of this type shall be approved by the Owner's Representative and shall not exceed 50 feet (15 m) in length.

   e. Removing bad seam and replacing with a strip of new material welded into place.

2. For any repair method, the following provisions shall be satisfied:

   a. Surfaces of the geomembrane which are to be repaired using extrusion methods shall be abraded no more than one hour prior to the repair.

   b. All surfaces shall be clean and dry at the time of the repair.

   c. All seaming equipment used in repairing procedures shall meet the requirements of the project manual.

   d. Patches or caps shall extend at least 6 inches (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches (75 mm).

4.6.4 Repair Verification: Each repair shall be numbered and logged. Each repair shall be nondestructively tested using the methods described in Section 4.5 as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 150 feet long may be of sufficient extent to require destructive test sampling, at the

discretion of the Owner's Representative. Failed tests indicate that the repair shall be redone and retested until a passing test results. The Owner's Representative shall observe all nondestructive testing of repairs and shall record the number of each repair, date, and test outcome.

4.6.5 Large Wrinkles: When seaming of the geomembrane is completed, and prior to placing overlying materials, the Owner's Representative shall indicate to the Installer which wrinkles should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation process, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. Wrinkles are considered to be large when the geomembrane can be folded over onto itself. This is generally the case for a wrinkle that extends 12 inches from the subgrade. Seams produced while repairing wrinkles shall be tested as outlined above.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Owner's Representative to assure that wrinkle formation is minimized.

## 4.7 GEOMEMBRANE PROTECTION

The quality assurance procedures indicated in this Section are intended only to assure that the installation of adjacent materials does not damage the geomembrane.

4.7.1 Soils: A copy of the specifications prepared by the Designer for placement of soils shall be given to the Owner's Representative. The Owner's Representative shall verify that these specifications are consistent with the state-of-practice such as:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32°F (0°C) nor above 104°F (40°C) unless otherwise specified.

2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

3. Equipment used for placing soil shall not be driven directly on the geomembrane.

4. A minimum thickness of 9 inches of soil is specified between a light dozer (ground pressure of 5 psi (35 kPa) or lighter) and the geomembrane.

5. In any areas travresed by any vehicles other than low ground pressure vehicles approved by the Owner's Representative, the soil layer shall have a minimum thickness of 3 feet (0.9 m). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

The Owner's Representative shall measure soil thickness and verify that the required thicknesses are present. The Owner's Representative must also verify that final thicknesses are consistent with the design and verify that placement of the soil is done in such a manner that geomembrane damage is unlikely. The Owner's Representative shall inform the Contractor if the above conditions are not fulfilled.

END OF SECTION

# APPENDIX C

# CALCULATIONS

# COVER SLOPE STABILITY

STABILITY OF COVER SOIL ABOVE A GEOMEMBRANE

PROJECT: CHAMPION LANDFILL CLOSURE PROJ. #: 97044
BY: GUY COTE

Problem: Determine factor-of-safety for given design parameters

Length of slope - $L := 220 \cdot ft$

Thickness of cover - $H := 1.5 \cdot ft$

Unit weight of soil(buoyant) - $\gamma := (120 - 62.4) \cdot \frac{lb}{ft^3}$

Sideslope angle - $\omega := 7.0 \cdot deg$

Friction angle of soil-to-geotextile - $\phi := 32 \cdot deg$

Friction angle of geotextile-to-geomembrane - $\delta := 21 \cdot deg$

Adhesion of soil-to-geomembrane - $CA := 0 \cdot \frac{lb}{ft^2}$

Cohesion of soil-to-soil - $C := 0 \cdot \frac{lb}{ft^2}$

Solution:

$a := .5 \cdot \gamma \cdot L \cdot H \cdot \sin(2 \cdot \omega)^2$

$a = 556 \cdot lb \cdot ft^{-1}$

$b := -\left(\gamma \cdot L \cdot H \cdot \cos(\omega)^2 \cdot \tan(\delta) \cdot \sin(2 \cdot \omega) + CA \cdot L \cdot \cos(\omega) \cdot \sin(2 \cdot \omega) + \gamma \cdot L \cdot H \cdot \sin(\omega)^2 \cdot \tan(\phi) \cdot \sin(2 \cdot \omega) \ldots \right.$
$\left. + 2 \cdot C \cdot H \cdot \cos(\omega) + \gamma \cdot H^2 \cdot \tan(\phi) \right)$

$b = -1.863 \cdot 10^3 \cdot lb \cdot ft^{-1}$

$c := (\gamma \cdot L \cdot H \cdot \cos(\omega) \cdot \tan(\delta) + CA \cdot L) \cdot (\tan(\phi) \cdot \sin(\omega) \cdot \sin(2 \cdot \omega))$

$c = 133 \cdot lb \cdot ft^{-1}$

$FS := \frac{-b + \sqrt{(b^2 - 4 \cdot a \cdot c)}}{(2 \cdot a)}$

$FS = 3.3$

Results: FS > 1, cover design is acceptable

REFERENCE: United States Environmental Protection Agency, "Design and Construction of RCRA/CERCLA Final Covers", EPA/625/4-91/025

Model #1: Stability of Cover Soil Above a Geomembrane

Consider a cover soil (usually a permeable soil like gravel, sand or silt) placed directly on a geomembrane at a slope angle of "ω". Two discrete zones can be visualized as seen in Figure 3. Here one sees a small passive wedge resisting a long, thin active wedge extending the length of the slope. It is assumed that the cover soil is a uniform thickness and constant unit weight. At the top of the slope, or at an intermediate berm, a tension crack in the cover soil is considered to occur thereby breaking communication with additional cover soil at higher elevations.

Resisting the tendency for the cover soil to slide is the adhesion and/or interface friction of the cover soil to the specific type of underlying geomembrane. The values of "$c_a$" and "δ" must be obtained from a simulated laboratory direct shear test as described earlier. Note that the passive wedge is assumed to move on the underlying cover soil so that the shear parameters "c" and "ϕ", which come from soil-to-soil friction tests, will also be required.

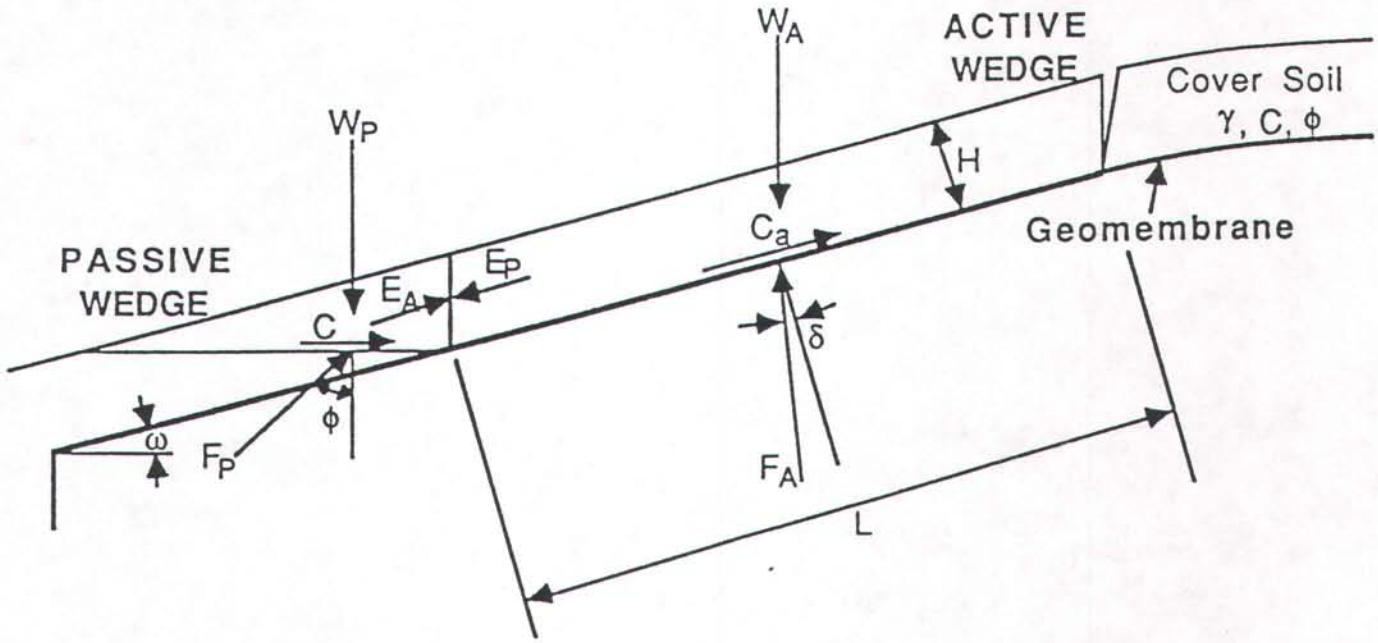


Figure 3 - Cross Section of Cover Soil on a Geomembrane Illustrating the Various Forces Involved on the Active and Passive Wedges

By taking free bodies of the passive and active wedges with the appropriate forces being applied, the following formulation for the stability factor-of-safety results, see Equation 3. Note that the equation is not an explicit solution for the factor-of-safety (FS), and must be solved indirectly. The complete development of the equation is given in Appendix "A".

$$(FS)^2 [0.5\,\gamma\, LH \sin^2(2\,\omega)] - (FS)[\gamma\, LH \cos^2\omega \tan\delta \sin(2\,\omega) + c_a L \cos\omega \sin(2\,\omega) + \gamma\, LH \sin^2\omega \tan\phi \sin(2\,\omega) + 2\,c\,H \cos\omega + \gamma H^2 \tan\phi] + [(\gamma LH \cos\omega \tan\delta + c_a L)(\tan\phi \sin\omega \sin(2\,\omega)] = 0 \quad (3)$$

Using $ax^2 + bx + c = 0$, where

$$a = 0.5\,\gamma\, LH \sin^2 2\omega$$

$$b = -[\gamma\, LH \cos^2\omega \tan\delta \sin(2\omega) + c_a L \cos\omega \sin(2\,\omega) + \gamma\, LH \sin^2\omega \tan\phi \sin(2\omega) + 2cH \cos\omega + \gamma\, H^2 \tan\phi]$$

$$c = (\gamma\, LH \cos\omega \tan\delta + c_a L)(\tan\phi \sin\omega \sin(2\omega))$$

the resulting factor-of-safety is as follows:

$$FS = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (4)$$

When the calculated factor-of-safety value falls below 1.0, a stability failure of the cover soil sliding on the geomembrane is to be anticipated. However, it should be recognized that seepage forces, seismic forces and construction placement forces have not been considered in this analysis and all of these phenomena tend to lower the factor-of-safety. Thus a value of greater than 1.0 should be targeted as being the minimum acceptable factor-of-safety. An example problem illustrating the use of the above equations follows:

Example Problem: Given a soil cover soil slope of $\omega = 18.4°$ (i.e., 3 to 1), $L = 300$ ft., $H = 3.0$ ft., $\gamma = 120$ lb/ft$^3$, $c = 300$ lb/ft$^2$, $c_a = 0$, $\phi = 32°$, $\delta = 14°$, determine the resulting factor-of-safety

Solution:

$$a = 0.5\,(120)\,(300)\,(3)\sin^2(36.8°)$$

$$= 19{,}400 \text{ lb/ft}$$

$$b = -[(120)\,(300)\,(3)\cos^2(18.4°)\tan(14°)\sin(36.8°) + 0 + (120)\,(300)\,(3)\sin^2(18.4°)\tan(32°)\sin(36.8°) + 2\,(300)\,(3)\cos(18.4°) + 120\,(9)\tan(32°)]$$

United States
Environmental Protection
Agency

Office of
Research and Development
Washington, DC 20460

EPA/625/4-91/025
May 1991

EPA

# Seminar Publication

# Design and Construction of RCRA/CERCLA Final Covers

**TABLE 5.5** FRICTION VALUES AND EFFICIENCIES (IN PARENTHESES) FOR (a) SOIL-TO-GEOMEMBRANE, (b) GEOMEMBRANE-TO-GEOTEXTILE, AND (c) SOIL-TO-GEOTEXTILE COMBINATIONS*

(a) Soil-to-geomembrane friction angles

| Geomembrane | Soil types | | |
|---|---|---|---|
| | Concrete sand ($\phi = 30°$) | Ottawa sand ($\phi = 28°$) | Mica schist sand ($\phi = 26°$) |
| EPDM | 24° (0.77) | 20° (0.68) | 24° (0.91) |
| PVC | | | |
| rough | 27° (0.88) | — | 25° (0.96) |
| smooth | 25° (0.81) | — | 21° (0.79) |
| CSPE | 25° (0.81) | 21° (0.72) | 23° (0.87) |
| HDPE | 18° (0.56) | 18° (0.61) | 17° (0.63) |

(b) Geomembrane-to-geotextile friction angle

| Geotextile | Geomembrane | | | | |
|---|---|---|---|---|---|
| | | PVC | | | |
| | EPDM | Rough | Smooth | CSPE | HDPE |
| nonwoven, needle-punched | 23° | 23° | 21° | 15° | 8° |
| nonwoven, melt-bonded | 18° | 20° | 18° | 21° | 11° |
| woven, monofilament | 17° | 11° | 10° | 9° | 6° |
| woven, slit film | 21° | 28° | 24° | 13° | 10° |

(c) Soil-to-geotextile friction angle

| Geotextile | Soil types | | |
|---|---|---|---|
| | Concrete sand ($\phi = 30°$) | Ottawa sand ($\phi = 28°$) | Mica schist sand ($\phi = 26°$) |
| nonwoven, needle-punched | 30° (1.00) | 26° (0.92) | 25° (0.96) |
| nonwoven, melt-bonded | 26° (0.84) | — | — |
| woven, monofilament | 26° (0.84) | — | — |
| woven, slit film | 24° (0.77) | 24° (0.84) | 23° (0.87) |

Source: After Martin, et al. [8]

*Efficiency values in parentheses are based on the relationship $E = (\tan \delta)/(\tan \phi)$

on smooth geotextiles giving the lowest friction values. For reference purposes, Part c of Table 5.5 gives the soil-to-geotextile friction values that are necessary for slope design of lined slopes with geotextiles under or over the liner.

The frictional behavior of geomembranes placed on clay soils is of considerable importance in the composite liners of waste landfills. Current requirements are for the

STORMWATER CALCULATIONS

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Champion Landfill No. 6 User: ghc Date: 08-28-97
County : Haywood State: NC Checked: ____ Date: _____
Subtitle: Area F
Subarea : A

| COVER DESCRIPTION | Hydrologic Soil Group A | B | C | D |
|---|---|---|---|---|
| | Acres (CN) | | | |
| FULLY DEVELOPED URBAN AREAS (Veg Estab.) | | | | |
| Open space (Lawns,parks etc.) | | | | |
| Good condition; grass cover > 75% | - | - | 2.4(74) | - |
| Total Area (by Hydrologic Soil Group) | | | 2.4 | |
| | | | ==== | |

SUBAREA: A TOTAL DRAINAGE AREA: 2.4 Acres WEIGHTED CURVE NUMBER: 74

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Champion Landfill No. 6 User: ghc Date: 08-28-97
County : Haywood State: NC Checked: ____ Date: _____
Subtitle: Area F
Subarea : B

| COVER DESCRIPTION | Hydrologic Soil Group A | B | C | D |
|---|---|---|---|---|
| | Acres (CN) | | | |
| FULLY DEVELOPED URBAN AREAS (Veg Estab.) | | | | |
| Open space (Lawns,parks etc.) | | | | |
| Good condition; grass cover > 75% | - | - | 2.4(74) | - |
| Total Area (by Hydrologic Soil Group) | | | 2.4 | |

SUBAREA: B TOTAL DRAINAGE AREA: 2.4 Acres WEIGHTED CURVE NUMBER: 74

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : Champion Landfill No. 6 User: ghc Date: 08-28-97
County : Haywood State: NC Checked: ____ Date: _____
Subtitle: Area F

---------- Subarea #1 - A ----------

| Flow Type | 2 year rain | Length (ft) | Slope (ft/ft) | Surface code | n | Area (sq/ft) | Wp (ft) | Velocity (ft/sec) | Time (hr) |
|---|---|---|---|---|---|---|---|---|---|
| Sheet | 3.8 | 110 | .07 | F | | | | | 0.143 |
| Shallow Concent'd | | 360 | .01 | U | | | | | 0.062 |
| Open Channel | | 500 | .04 | | .04 | 3 | 6.3 | | 0.031 |
| | | | | | | | | Time of Concentration = | 0.24* |
| | | | | | | | | | ===== |

---------- Subarea #2 - B ----------

| Flow Type | 2 year rain | Length (ft) | Slope (ft/ft) | Surface code | n | Area (sq/ft) | Wp (ft) | Velocity (ft/sec) | Time (hr) |
|---|---|---|---|---|---|---|---|---|---|
| Sheet | 3.8 | 220 | .12 | F | | | | | 0.200 |
| Open Channel | | 370 | .02 | | .04 | 3 | 6.3 | | 0.032 |
| | | | | | | | | Time of Concentration = | 0.23* |
| | | | | | | | | | ===== |

--- Sheet Flow Surface Codes ---

| | | | |
|---|---|---|---|
| A Smooth Surface | F Grass, Dense | --- Shallow Concentrated --- | |
| B Fallow (No Res.) | G Grass, Burmuda | --- | Surface Codes --- |
| C Cultivated < 20 % Res. | H Woods, Light | | P Paved |
| D Cultivated > 20 % Res. | I Woods, Dense | | U Unpaved |
| E Grass-Range, Short | J Range, Natural | | |

* - Generated for use by TABULAR method

TABULAR HYDROGRAPH METHOD Version 2.00

Project : Champion Landfill No. 6 User: ghc Date: 08-28-97
County : Haywood State: NC Checked: ____ Date: _____
Subtitle: Area F

Total watershed area: 0.008 sq mi Rainfall type: II Frequency: 100 years

| | Subareas A | Subareas B |
|---|---|---|
| Area(sq mi) | 0.00* | 0.00* |
| Rainfall(in) | 8.0 | 8.0 |
| Curve number | 74* | 74* |
| Runoff(in) | 4.93 | 4.93 |
| Tc (hrs) | 0.24* | 0.23* |
| (Used) | 0.20 | 0.20 |
| TimeToOutlet | 0.00 | 0.00 |
| Ia/P | 0.09 | 0.09 |
| (Used) | 0.10 | 0.10 |

| Time (hr) | Total Flow | Subarea Contribution to Total Flow (cfs) A | B |
|---|---|---|---|
| 11.0 | 0 | 0 | 0 |
| 11.3 | 2 | 1 | 1 |
| 11.6 | 2 | 1 | 1 |
| 11.9 | 8 | 4 | 4 |
| 12.0 | 14 | 7 | 7 |
| 12.1 | 28 | 14 | 14 |
| 12.2 | 30P | 15P | 15P |
| 12.3 | 18 | 9 | 9 |
| 12.4 | 10 | 5 | 5 |
| 12.5 | 6 | 3 | 3 |
| 12.6 | 4 | 2 | 2 |
| 12.7 | 4 | 2 | 2 |
| 12.8 | 4 | 2 | 2 |
| 13.0 | 2 | 1 | 1 |
| 13.2 | 2 | 1 | 1 |
| 13.4 | 2 | 1 | 1 |
| 13.6 | 2 | 1 | 1 |
| 13.8 | 2 | 1 | 1 |
| 14.0 | 2 | 1 | 1 |
| 14.3 | 2 | 1 | 1 |
| 14.6 | 2 | 1 | 1 |
| 15.0 | 2 | 1 | 1 |
| 15.5 | 0 | 0 | 0 |
| 16.0 | 0 | 0 | 0 |
| 16.5 | 0 | 0 | 0 |
| 17.0 | 0 | 0 | 0 |
| 17.5 | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| 18.0 | 0 | 0 | 0 |
| 19.0 | 0 | 0 | 0 |
| 20.0 | 0 | 0 | 0 |
| 22.0 | 0 | 0 | 0 |
| 26.0 | 0 | 0 | 0 |

P - Peak Flow * - value(s) provided from TR-55 system routines

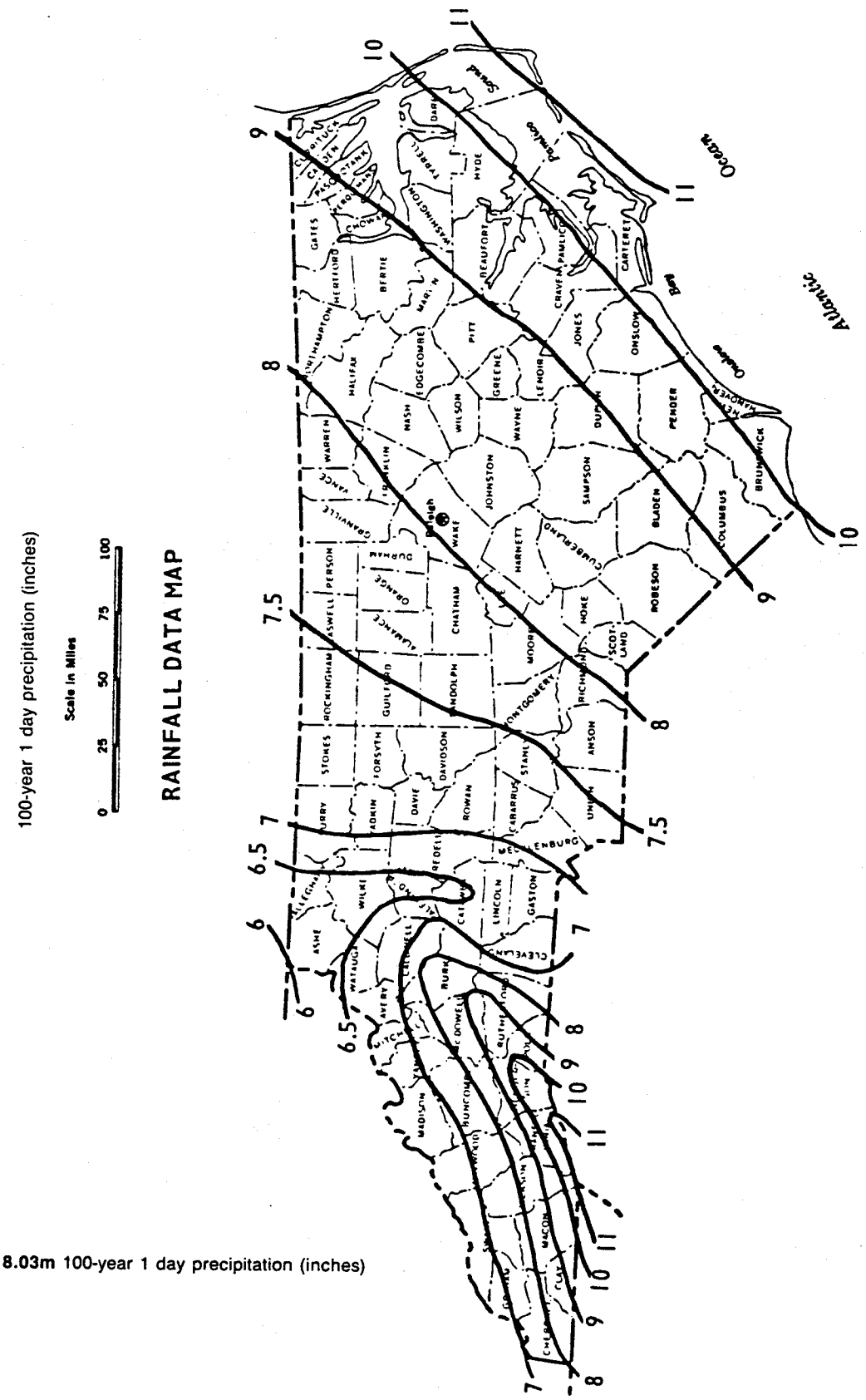


**Figure 8.03m** 100-year 1 day precipitation (inches)

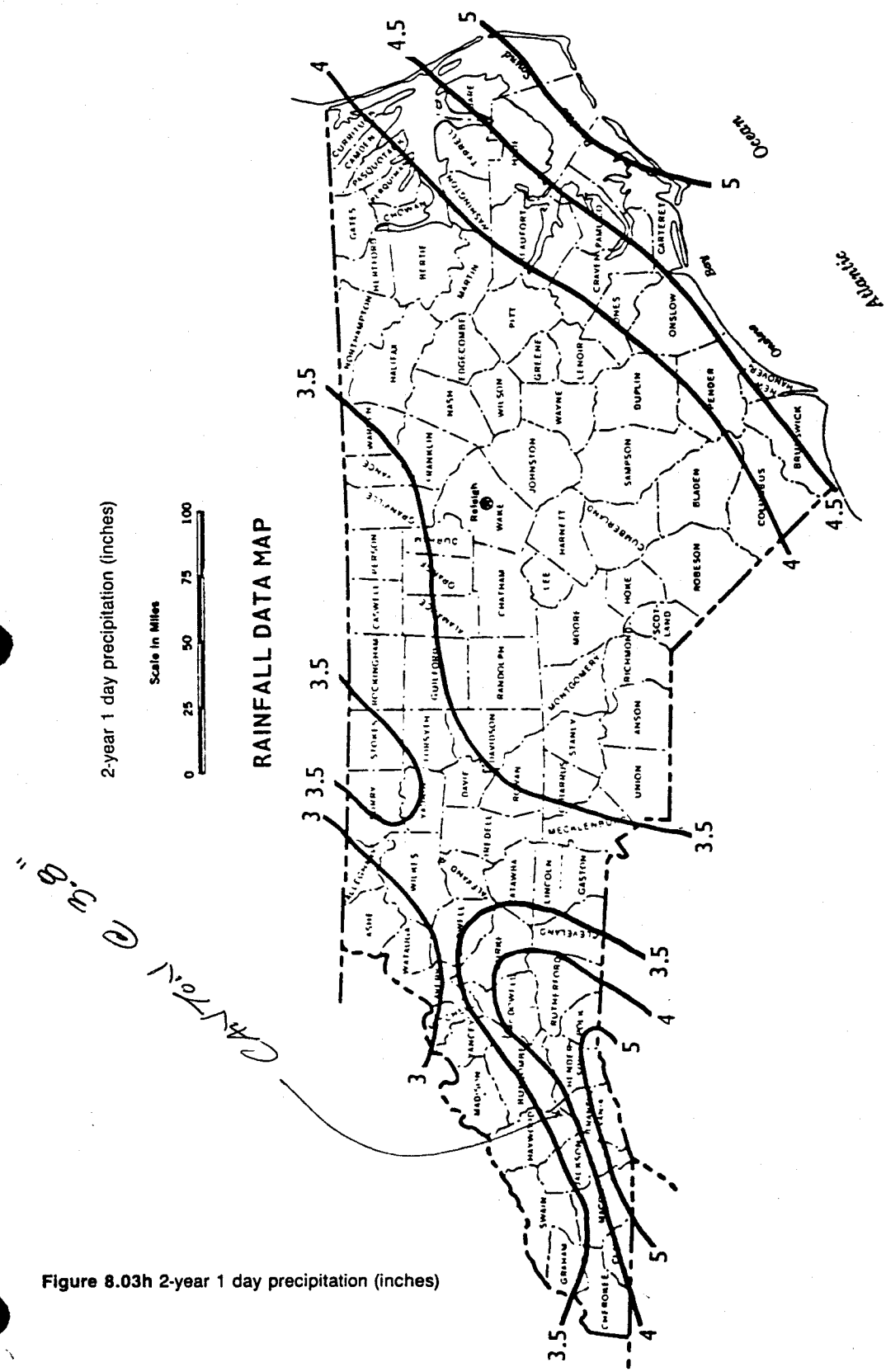


**Figure 8.03h** 2-year 1 day precipitation (inches)

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : CHAMPION - LANDFILL NO. 6 User: ghc Date: 08-21-97
County : HAYWOOD State: NC Checked: ____ Date: _____
Subtitle: FINAL GRADE - G
Subarea : A

| COVER DESCRIPTION | Hydrologic Soil Group A | B | C | D |
|---|---|---|---|---|
| | Acres (CN) | | | |
| FULLY DEVELOPED URBAN AREAS (Veg Estab.) | | | | |
| Open space (Lawns,parks etc.) | | | | |
| Good condition; grass cover > 75% | - | - | 1.8(74) | - |
| Total Area (by Hydrologic Soil Group) | | | 1.8 | |

SUBAREA: A TOTAL DRAINAGE AREA: 1.8 Acres WEIGHTED CURVE NUMBER: 74*

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : CHAMPION - LANDFILL NO. 6 User: ghc Date: 08-21-97
County : HAYWOOD State: NC Checked: ____ Date: _____
Subtitle: FINAL GRADE - G

| Flow Type | 2 year rain | Length (ft) | Slope (ft/ft) | Surface code | n | Area (sq/ft) | Wp (ft) | Velocity (ft/sec) | Time (hr) |
|---|---|---|---|---|---|---|---|---|---|
| Sheet | 3.8 | 160 | .06 | F | | | | | 0.205 |
| Shallow Concent'd | | 500 | .076 | U | | | | | 0.031 |
| | | | | | | | | Time of Concentration = | 0.24* |

--- Sheet Flow Surface Codes ---

| | | |
|---|---|---|
| A Smooth Surface | F Grass, Dense | --- Shallow Concentrated --- |
| B Fallow (No Res.) | G Grass, Burmuda | --- Surface Codes --- |
| C Cultivated < 20 % Res. | H Woods, Light | P Paved |
| D Cultivated > 20 % Res. | I Woods, Dense | U Unpaved |
| E Grass-Range, Short | J Range, Natural | |

* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : CHAMPION - LANDFILL NO. 6 User: ghc Date: 08-21-97
County : HAYWOOD State: NC Checked: ____ Date: _____
Subtitle: FINAL GRADE - G

Data: Drainage Area : 1.8 * Acres
Runoff Curve Number : 74 *
Time of Concentration: 0.24 * Hours
Rainfall Type : II
Pond and Swamp Area : NONE

| Storm Number | 1 | 2 | 3 |
|---|---|---|---|
| Frequency (yrs) | 10 | 25 | 100 |
| 24-Hr Rainfall (in) | 6 | 7 | 8 |
| Ia/P Ratio | 0.12 | 0.10 | 0.09 |
| Used | 0.12 | 0.10 | 0.10 |
| Runoff (in) | 3.18 | 4.04 | 4.93 |
| Unit Peak Discharge (cfs/acre/in) | 1.148 | 1.162 | 1.162 |
| Pond and Swamp Factor 0.0% Ponds Used | 1.00 | 1.00 | 1.00 |
| Peak Discharge (cfs) | 7 | 8 | 10 |

* - Value(s) provided from TR-55 system routines

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : CHAMPION - LANDFILL NO. 6 User: ghc Date: 08-21-97
County : HAYWOOD State: NC Checked: ____ Date: _____
Subtitle: Area H
Subarea : A

| COVER DESCRIPTION | Hydrologic Soil Group A | B | C | D |
|---|---|---|---|---|
| | | Acres (CN) | | |
| FULLY DEVELOPED URBAN AREAS (Veg Estab.) | | | | |
| Open space (Lawns,parks etc.) | | | | |
| Good condition; grass cover > 75% | - | - | 3.5(74) | - |
| Streets and roads | | | | |
| Gravel (w/ right-of-way) | - | 2.2(85) | - | - |
| Total Area (by Hydrologic Soil Group) | | 2.2 | 3.5 | |

SUBAREA: A TOTAL DRAINAGE AREA: 5.7 Acres WEIGHTED CURVE NUMBER: 78*

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : CHAMPION - LANDFILL NO. 6 User: ghc Date: 08-21-97
County : HAYWOOD State: NC Checked: ____ Date: _____
Subtitle: Area H

| Flow Type | 2 year rain | Length (ft) | Slope (ft/ft) | Surface code | n | Area (sq/ft) | Wp (ft) | Velocity (ft/sec) | Time (hr) |
|---|---|---|---|---|---|---|---|---|---|
| Sheet | 3.8 | 270 | .05 | F | | | | | 0.335 |
| Shallow Concent'd | | 1020 | .02 | U | | | | | 0.124 |
| | | | | | | | | Time of Concentration = | 0.46* |
| | | | | | | | | | ===== |

--- Sheet Flow Surface Codes ---

| | | |
|---|---|---|
| A Smooth Surface | F Grass, Dense | --- Shallow Concentrated --- |
| B Fallow (No Res.) | G Grass, Burmuda | --- Surface Codes --- |
| C Cultivated < 20 % Res. | H Woods, Light | P Paved |
| D Cultivated > 20 % Res. | I Woods, Dense | U Unpaved |
| E Grass-Range, Short | J Range, Natural | |

* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : CHAMPION - LANDFILL NO. 6 User: ghc Date: 08-21-97
County : HAYWOOD State: NC Checked: ____ Date: _____
Subtitle: Area H

Data: Drainage Area : 5.7 * Acres
Runoff Curve Number : 78 *
Time of Concentration: 0.46 * Hours
Rainfall Type : II
Pond and Swamp Area : NONE

| Storm Number | 1 | 2 | 3 |
|---|---|---|---|
| Frequency (yrs) | 10 | 25 | 100 |
| 24-Hr Rainfall (in) | 6 | 7 | 8 |
| Ia/P Ratio | 0.09 | 0.08 | 0.07 |
| Used | 0.10 | 0.10 | 0.10 |
| Runoff (in) | 3.58 | 4.47 | 5.39 |
| Unit Peak Discharge (cfs/acre/in) | 0.863 | 0.863 | 0.863 |
| Pond and Swamp Factor 0.0% Ponds Used | 1.00 | 1.00 | 1.00 |
| Peak Discharge (cfs) | 18 | 22 | 27 |

* - Value(s) provided from TR-55 system routines

LANDOWNER CHAMPION ADDRESS CANTON, NC

PROJECT AREA H CULVERT BY MHC DATE ___/___/___

********** IMPUTS FOR CURCULAR CULVERT ANALYSIS **********

| | | |
|---|---|---|
| MANNINGS COEFFICIENT PVC=.009 R/C=.013 CMP<=.025 | | N= .013 |
| CULVERT DIAMETER | (FT) | D= 2.5 |
| HEADWATER ABOVE UPSTREAM ENTRANCE INVERT | (FT) | DE= 4 |
| TAILWATER ABOVE OUTLET INVERT => 0 | (FT) | DO= 0 |
| LENGTH OF CULVERT PIPE | (FT) | LP= 50 |
| DROP ALONG CULVERT LENGTH (INVERT TO INVERT) | (FT) | PD= .5 |
| ENTRANCE LOSS COEFFICIENT | | KE= .8 |

30" OK

********** CULVERT OUTLET CONTROL (PRESSURE FLOW) EXISTS **********

| | | |
|---|---|---|
| CULVERT CAPACITY ********** | (CFS) | Q= 42.44 |
| PIPE VELOCITY | (FPS) | V= 8.649999 |
| NEUTRAL SLOPE | (FT/FT) | SN= .0107 |
| ACTUAL SLOPE ON CULVERT PIPE | (FT/FT) | SO= .01 |

DO YOU WANT TO CHANGE A VARIABLE Y/N ?

LANDOWNER _____ ADDRESS _____

PROJECT _____ BY _____ DATE ___/___/___

********** IMPUTS FOR CURCULAR CULVERT ANALYSIS **********

| | | |
|---|---|---|
| MANNINGS COEFFICIENT PVC=.009 R/C=.013 CMP<=.025 | | N= .013 |
| CULVERT DIAMETER | (FT) | D= 2.5 |
| HEADWATER ABOVE UPSTREAM ENTRANCE INVERT | (FT) | DE= 4 |
| TAILWATER ABOVE OUTLET INVERT => 0 | (FT) | DO= 0 |
| LENGTH OF CULVERT PIPE | (FT) | LP= 50 |
| DROP ALONG CULVERT LENGTH (INVERT TO INVERT) | (FT) | PD= .5 |
| ENTRANCE LOSS COEFFICIENT | | KE= .8 |

********** CULVERT OUTLET CONTROL (PRESSURE FLOW) EXISTS **********

| | | |
|---|---|---|
| CULVERT CAPACITY ********** | (CFS) | Q= 42.44 |
| PIPE VELOCITY | (FPS) | V= 8.649999 |
| NEUTRAL SLOPE | (FT/FT) | SN= .0107 |
| ACTUAL SLOPE ON CULVERT PIPE | (FT/FT) | SO= .01 |

DO YOU WANT TO CHANGE A VARIABLE Y/N ?

RIP RAP CHANNEL DESIGN FOR H OUTLET



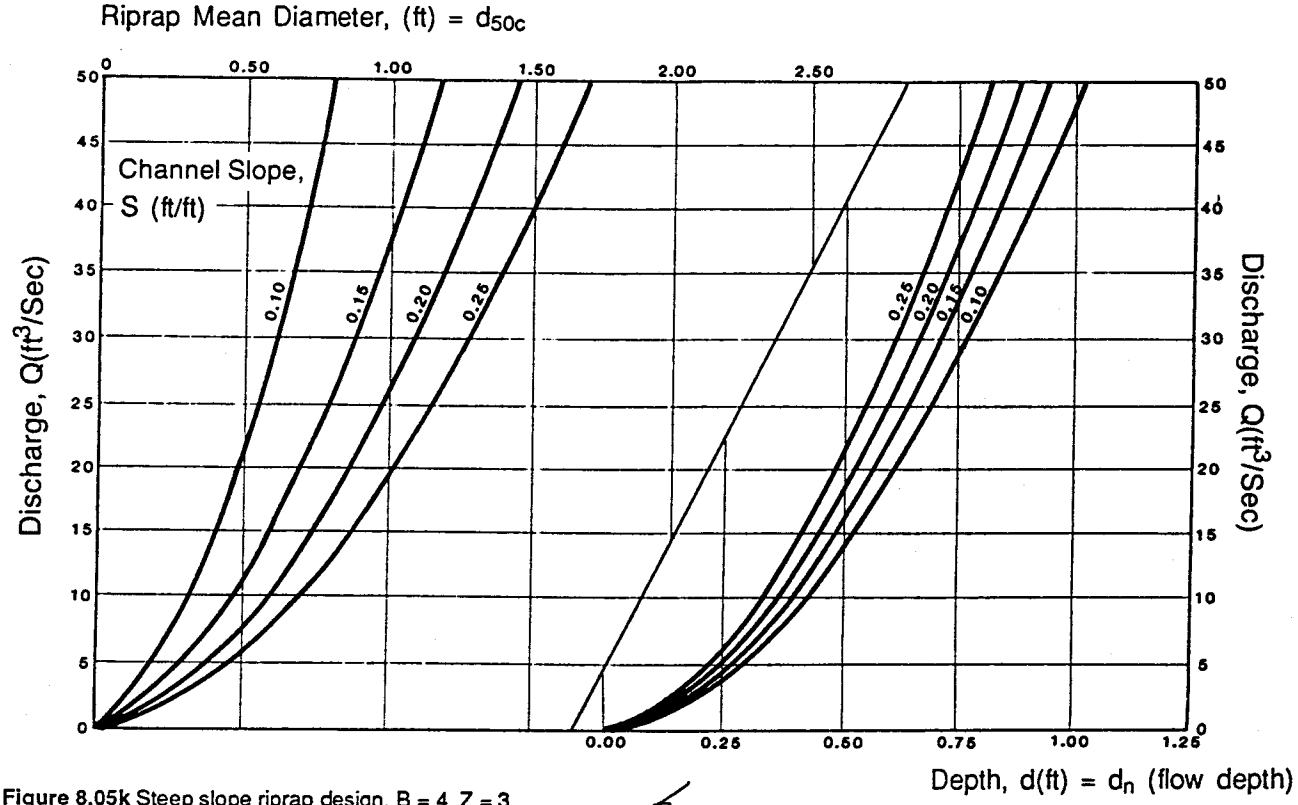


Figure 8.05k Steep slope riprap design, B = 4, Z = 3.

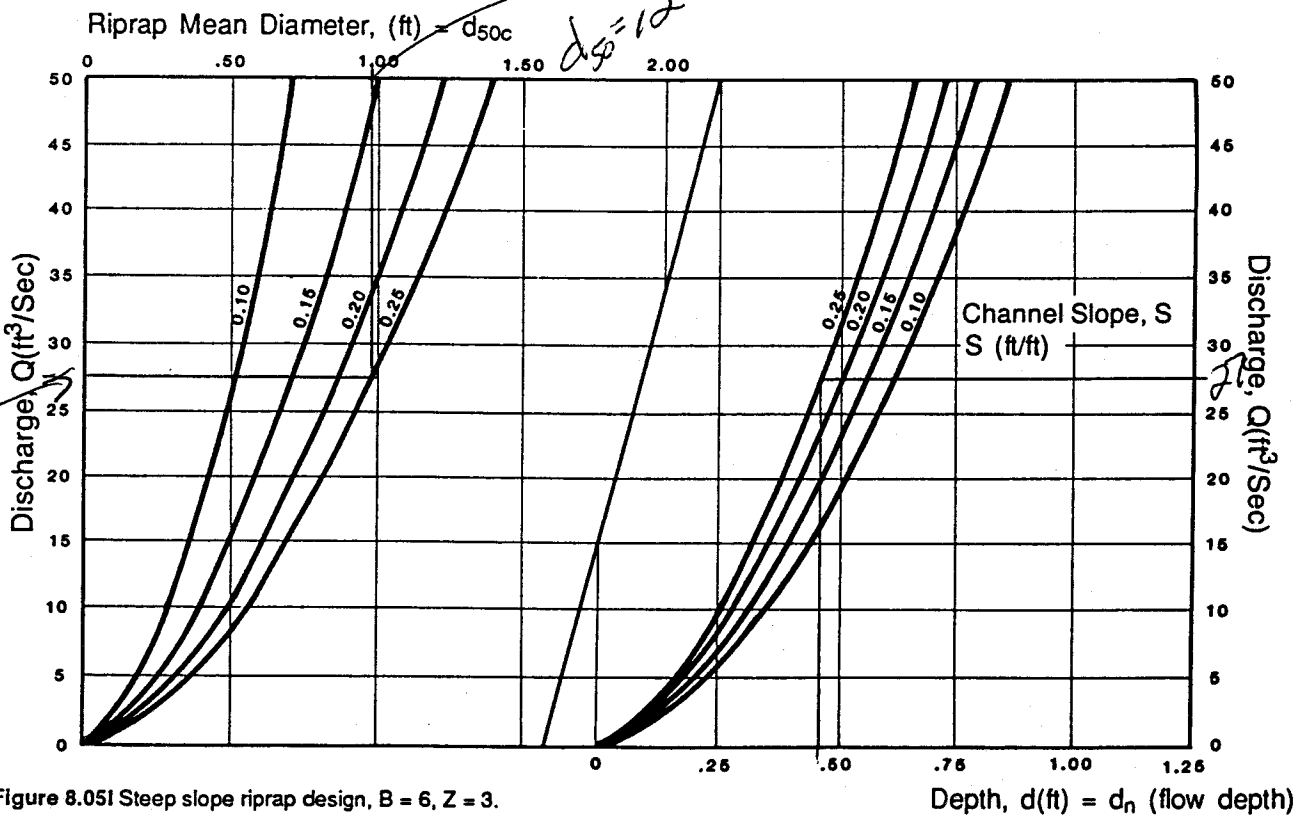


Figure 8.05l Steep slope riprap design, B = 6, Z = 3.

"Drawings Under Seperate Cover"